Review Article

Experimental studies of food choices and palatability responses in European subjects exposed to the Umami taste

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In the Western world, consumers have only recently learned to discriminate the Umami taste, although they have enjoyed its contribution to the palatability of traditional dishes for centuries. The flavor enhancing properties of MSG have been scientifically investigated in European subjects. By adding MSG to such foods as soups, their content in sodium can be decreased without altering palatability, thus favoring a net decrease in sodium intake. Consumers presented with a novel food often have to get accustomed to the new taste before they acquire a preference for the food. A study showed that when such novel foods are added with some appropriate amount of MSG, consumers acquire a preference for them more rapidly. In elderly persons, the addition of MSG to nutritionally valuable foods (soups, vegetables, starches) did induce an increase of intake of MSG-added foods. Total meal size, however, was not affected, since the increased intake of MSG-containing foods was followed by a decreased consumption of foods served later in the meal, such as desserts. The same observations were repeated in hospitalized diabetic patients. Again, the patients ingested more healthy MSG-containing foods and less of other foods, with the same total meal energy intake. These two studies suggested that MSG could be used to stimulate appropriate food choices in certain populations.

Key Words: Umami taste, palatability, sodium, meal size, food preferences

INTRODUCTION

Monosodium glutamate (MSG) is well-known as a flavour enhancer. Asian consumers learn to discriminate and appreciate its taste, called Umami, from early childhood. In the Western world, consumers have only recently learned to discriminate the Umami taste, although they have enjoyed its contribution to the palatability of several traditional dishes and foods for centuries. MSG is a crucial component of the taste of cheese, sea foods, meat broths, etc. It is present in important quantities in several popular foods and every one ingests large amounts of it in the context of traditional Eastern or Western cuisines.

BASIC MECHANISMS

Since the discovery of Umami substances such as L-glutamate salts by Ikeda in 1908, numerous brilliant studies have investigated the receptor and transduction mechanisms that allow the Umami flavour to be perceived.[1] Recent developments of bioresearch techniques have revealed the representation of umami in the taste cortex of primates, highlighting the crucial contribution of the orbitofrontal cortex, a secondary taste area.[2] In addition, when MSG is given in combination with a consonant savory odour (such as that of a vegetable for example), functional brain imaging with fMRI shows that MSG plus the odour act synergistically to enhance the activation of the medial orbitofrontal cortex and the pregenual cingulate cortex more than either stimulus presented separately, in conscious human subjects.[3]

THE "FIFTH TASTE"

These impressive works often present Umami as "the fifth taste", along with the four classic ones (sweet, salty, bitter and sour), with distinct perception mechanisms. Beside this basic specificity of the Umami taste, it is clear also that, like sweetness and saltiness, the Umami taste often acts to improve or enhance the acceptance response to a variety of foods. An important question is to establish whether such effects on affective responses can affect behaviour. This question is particularly important in the present food context, as overeating triggered by numerous highly palatable and easily accessible foods may critically contribute to the worldwide "obesity epidemics".

MSG AS A FLAVOUR ENHANCER

The flavour enhancing properties of MSG have been scien

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tifically investigated in many contexts.[4] For example, the addition of MSG in several savoury foods enhances their palatability level, an effect that can be evidenced by asking volunteers to taste and rate samples of the same food containing varying concentrations of MSG. For each food, there is an optimum MSG concentration. Some foods, however, are not improved by the addition of MSG: sweet foods in particular and perhaps some particularly bitter foods.

The optimal concentration of MSG substances in a food also varies according to individual tastes. Exactly as for sweetness and saltiness, the optimum concentration of Umami taste can vary widely between individual consumers. Our studies carried out in Europeans suggest that preferred concentrations (0.6 to 1.2%) tend to be somewhat higher than optimal concentrations reported by Asian consumers. This may be due to the relative deficit in awareness of the distinctive Umami taste in Western consumers, or else to the fact that oral sensation varies with genetics and gene-environment interactions.[5] Although a genetic difference between populations in the sensitivity to MSG taste remains to be demonstrated, it is clear that the taste category "Umami" is not spontaneously recognised as such by European consumers. Many Western consumers are aware of the so-called "Chinese Restaurant Syndrome" and attribute it to the use (or abuse) of MSG in Asian cooking; however the same individuals are unable to describe the particular taste of Umami substances and are not aware that MSG is present in their every day diet in substantial amounts. They have never noticed that the ingestion of mushrooms or parmesan cheese, two popular foods that are especially rich in free MSG, is followed by symptoms of any kind, let alone the symptoms most often associated with the "Chinese Restaurant Syndrome".

Individual sensory differences are large even within the European population and participants in scientific studies of the taste and properties of Umami substances often have to be trained to recognise the specific taste. Some consumers like it, again at varying concentrations, some consumers seem indifferent to it, and some even dislike it. Nevertheless, as the results of many studies clearly show, most people are sensitive to its flavour-enhancing properties. A recent study in Polish volunteers suggested that the endogenous glutamate level in saliva could affect acceptability responses to MSG.[6] People with low endogenous salivary glutamate rated high MSG solutions more unpleasant than people with higher salivary glutamate. The determinants of the affective response to the Umami taste and its inter-individual differences thus remain to be investigated. The contributions of genetic and/or environmental factors must be explored further. It should be remembered also that, while sensory studies using solutions of various taste substances are interesting, their results may have little to do with the acceptance or preference responses of the same subjects to the same substances in actual foods.

MSG AND SODIUM CHLORIDE (SALT)

One very interesting effect of MSG is its interaction with sodium chloride, table salt, in many food contexts. Numerous experiments have demonstrated that by adding some MSG to such foods as soups for example, the amount of salt used could be decreased considerably without altering palatability. This was clear in a study of acceptance of low-salt soups.[7] The palatability ratings for such soups were higher when they contained Umami. This was observed both in subjects who preferred high salt concentrations in soup, and in subjects who preferred low salt concentrations.

We carried out a similar study in healthy French adults, using a very popular food that typically contains much salt: meat pâté. We were able to show that adding MSG to this food allowed a good level of palatability to be maintained even when the NaCl content was decreased (unpublished results).

The end result of this interaction is a potential net decrease in sodium intake since MSG, which contains less sodium than salt, maintains or even enhances the palatability of low salt products. This effect has to be demonstrated over medium to long term periods. The potential health benefits associated with long term decrease in sodium intake obtained thanks to the use of MSG deserve consideration.

MSG AND NOVEL FOODS

When consumers are presented with a novel, unfamiliar food, their immediate response to the food depends on the sensory quality of the food. Some foods have immediate appeal and can be ingested in large amounts; other food don't. Over time, following repeated ingestions, consumers adapt to their familiar foods and learn to adjust their intake to their bodily needs according to the energy and nutrient content of the food. Even foods that are not appealing on the first exposure can thus become very palatable. It is generally believed that a person's individual hierarchy of food preferences is the result of such a learning process.

Very often, an unfamiliar food that is presented for the first time may not be appreciated, due to a phenomenon related to neophobia: a reluctance to ingest unknown substances. In modern societies, novel foods are developed and presented to consumers who are confronted with literally thousands of novel foods each year, among which they have to select in order to obtain a satisfactory balanced diet. Can the use of MSG play a role in the development of food acceptance and preference? A scientific study carried out in healthy adults has shown that, beyond the immediate effect on palatability, consumers acquire acceptance responses for novel foods more rapidly when these foods contain some appropriate amount of MSG. Two experimental foods were developed by a professional cook. These foods were unfamiliar to the participants in the study and were of medium palatability, so that any potential effect of MSG could be identified. Enhanced palatability responses due to MSG were evidenced not only by a more abundant intake of these foods in the first few weeks of exposure to the foods, but also by other indices of palatability, such as accelerated rate of intake.[8]

MSG AND FOOD CHOICES AT MEAL TIMES

If many foods taste better when MSG is added to them, then there could be a risk of inducing over-consumption

of these foods and perhaps over-intake of energy leading to weight gain. This hypothesis was first tested in consumers who reportedly eat little and may be more exposed to the risks of under than overintake. A population of elderly persons (mean age 84 years) living in a specialized home was tested over one year during successive meals. The addition of MSG to nutritionally valuable savoury foods (soups, vegetables, starches) did induce an increase of intake of MSG-added foods.[9] Total meal size, however, was not affected since the increased intake of MSG-containing foods was followed by a decreased consumption of foods served later in the meal, such as sweet desserts. In elderly subjects, it appeared that food choices were merely re-oriented as a result of selective use of MSG while energy intake was unaffected.

Since using MSG in healthy foods consumed in the context of a meal did not lead to undesirable consequences in the elderly, the same experimental paradigm was used in other populations at risk of overeating. We repeated the protocol in a group of hospitalised diabetic patients.[10] In diabetes mellitus, patients are encouraged to select foods of good nutritional value as a part of their treatment. Patients with type 2 diabetes mellitus are often overweight and it is important for them to select low energy density foods that will provide good satiety. Patients with type 1 diabetes are usually lean but they also need to select their foods carefully since their pancreas can no longer secrete insulin; consequently they have to inject insulin before eating and it is highly important for them to select carbohydrate-rich foods that will optimize the effects of insulin injections. In one study carried out in patients with diabetes, lunch meals were observed under controlled hospital conditions. The hospital dieticians selected some foods according to their beneficial impact on the diabetic diet (low glycemic index starches, vegetables) and these foods were added with an appropriate amount of MSG, while other foods (e.g. desserts) were left unaltered. Again, the patients ingested more MSG containing foods and less of other foods, with the same total meal energy intake at lunch. These two studies on elderly persons and patients with diabetes suggested that MSG could be used, for dietetic purposes, to stimulate appropriate food choices in certain populations. The above experiments occurred under hospital meal conditions, with limited food choices. All the foods offered to the patients had been previously selected by competent dieticians and, although the addition of some MSG could potentially affect meal composition, the final meal nutritional content could not deviate greatly from recommendations.

What would happen in the context of a "normal" "every day" meal, in which food choices could be made from a broad selection of varied high palatability products, rather than from just a few pre-selected items? In such a meal context, would the addition of some MSG to vegetables and starches orient food selection, again inducing a more abundant selection of MSG-added foods and a decreased intake of other (potentially very palatable) foods eaten later in the meal? An experimental study investigated this question. Forty healthy young adults participated in several lunch meals served under laboratory conditions so that intake could be precisely measured. Meals were composed of numerous items traditionally served in French 4-course lunches. MSG was added to some of these foods (appetizer, meat, vegetable) while other foods were unaltered. All foods were presented simultaneously as a buffet and the subjects were invited to make their own selection, and freely decide how much of what foods they were willing to ingest. Over all experimental conditions, it appeared that although MSG did enhance palatability and intake of certain savoury foods (e.g. intake of chicken was increased four-fold in women, when MSG was added to it), such an effect did not prevent the strong stimulating effects of other flavours (e.g. chocolate, sugar) to affect behaviour, and meal composition was not systematically modified as a function of the presence of MSG in certain foods.

In conclusion, MSG does exert clear enhancing effects on the palatability of certain foods, but these effects occur in the global context of food stimulation at the time of intake: in a context of strong and possibly competing sensory influences, the impact of MSG on intake may be masked or remain non-significant. If MSG were to be used in a therapeutic context to affect food selection, then the presence of other high palatability, but less nutritionally desirable foods at meal times should be controlled.

MSG AND DIETARY FAT INTAKE

Studies suggest that MSG can be used, for dietetic purposes, to stimulate appropriate food choices in certain populations. Nutrition experts recommend a moderate or low dietary fat intake. This advice is not widely followed because low-fat foods are generally less palatable than full fat ones. We tested the possibility that, as it does with salt, MSG could be used to maintain the palatability of fat-reduced foods. In normal weight or overweight healthy adults, we compared various foods (soup, mashed potatoes and pasta) under three conditions: full-fat; 30% fat reduced, and 30% fat reduced plus added MSG. Each one of 40 participants was tested under all conditions in successive meals, and served as his/her own control. Preferred fat contents in each of the three experimental foods were established for each participant by sensory evaluation pre-tests. The preferred concentration of MSG in the same foods containing 30% less fat was also identified for each participant and each food by sensory evaluation pre-tests. Tests of *ad libitum* intake confirmed that reducing the participant-specific optimal fat content of the foods by 30% represented a significant decrease in energy and fat intake for pasta and mashed potatoes (but not for soup). It also affected palatability. The addition of participant-specific optimal MSG amounts to the fat-reduced foods reinstated some of the palatability, while maintaining the decrease in ingested fat and energy. However, much variability was observed between foods and between participants. No specific effect could be attributed to the participant's body weight status (obese versus normal weight), but gender significantly affected palatability and intake. These complex results suggest that MSG could be added to fat-reduced foods in a strategy to facilitate the spontaneous choice of low-fat products. The circumstances allowing such a strategy to produce biologically significant changes in the diet remain to be explored further. It is likely that an interaction of several factors

(gender, type of food, optimal fat content, optimal MSG content, and maybe others) would affect the ultimate intake behavior and consequently the dietary benefit of such a strategy. More research is clearly needed in order to assess the impact of numerous factors in such a mechanism, which seems much more complex than the interaction between sodium chloride and MSG. Given the high energy density of fat and the potential role of fat in the excessive energy intake leading to obesity, investigating whether MSG could help increasing the appeal of lower fat foods may prove a worthwhile, although difficult, task.

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AUTHOR DISCLOSURE

France Bellisle, no conflicts of interest.

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