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Food Composition and Human Behaviour*

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ABSTRACT

This brief review deals with food components that may influence behaviour by non-immunological mechanisms. Such components are classed as anaphylactoid, pharmacological and psychoactive, and the effects as stimulatory, depressant or hallucinatory though the latter category includes changes in mood not associated with hallucination at the concentrations of substances present in foodstuffs. The main categories dealt with are immunological mediators, additives, vasoactive amines, xanthines, a range of phenethylamine derivatives and various glycoalkaloids. It is suggested that food choice may be as much influenced by the behavioural consequences of food components as by the more conventional attributes such as appearance, flavour and learned preference.

INTRODUCTION

The role of foodstuffs in human behaviour has been a controversial subject since the 1930s when it was first suggested that behavioural problems could arise from allergy to food components. The controversy stemmed from the inability of the proponents of the hypothesis to produce objective evidence of an immune basis for the claim and from the similarity of the symptoms described to those associated with psychoneurosis, never a popular illness with physicians (May, 1984). The debate continues today and has been heightened by claims that behavioural problems in children can be induced by certain food additives or, alternatively, by the nutritional deficiency of

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processed foods. Such views have been accentuated by those with anti-industrial or political motives and have been given widespread publicity in press and television reports. The resultant furore has served to obscure the scientific basis that might exist for such reactions and to divert attention from the psychoactive substances that undoubtedly occur in foods.

In attempting to classify behavioural responses to food, one problem relates to the undoubted changes in mood and behaviour that can result from the existence in an individual of pain (such as headache or joint pain), abdominal discomfiture or itchiness. Particularly in children, when a precise description of the symptom is not possible, the observer, especially an anxious parent, may not perceive the underlying cause of irritable or unruly or depressed behaviour. Consequently a classification of behavioural change will not be attempted here and only the possible sources of such change identified. Nor will syndromes that have a definite immunologic cause be addressed. Failure to do this may result in errors of classification because it is not possible to demonstrate consistently the presence of a reactive antibody even though it occurs occasionally (Lessof *et al.*, 1984). Thus, the technology of immunology may still not be adequate to detect all the changes that might occur in food allergies.

The non-immune reactions to food that result in behavioural changes may be classified (Table 1) as:

1 Anaphylactoid, due to the release of mediators;
2 Pharmacological;
3 Psychoactive.

TABLE 1
Non-Immune Reactions to Foods

1. Anaphylactoid (Mediator release)		
	i. Histamine release	—Egg white
		Strawberry
		Shellfish
		? Tartrazine (high dose)
	ii. Histamine excess	—Tuna/Mackerel
		Cheese
	iii. Exercise	
	iv. Oral Urticaria	—BHA
		BHT
		Azo-dyes
		Benzoates
	v. Bronchospasm	—Aspirin/Tartrazine
		Sulphite
2. Pharmacological effects		
3. Psychoactive effects		

ANAPHYLACTOID EFFECTS

It is now well recognised that certain foods and food components may cause the release into the circulation of histamine, serotonin or prostaglandins that are normally involved in the instigation of inflammatory or immunological reactions. Thus an allergic response may be simulated where no immune reaction is involved. Foods commonly incriminated are egg white, strawberries and shellfish. Histamine intoxication from the ingestion of poorly preserved scrombroid fish (tuna, mackerel) is also well recognised. The fullblown syndrome may include urticaria, asthma, and gastrointestinal effects, but milder forms may exhibit little more than gastrointestinal discomfort, headache and anxiety (Anderson, 1984).

Similar reactions have been ascribed to some food additives such as tartrazine (in individuals known to react to acetylsalicylic acid) the butylated antioxidants, sulphites and monosodium glutamate. Such reactions are best regarded as idiosyncratic—occurring in susceptible individuals—but are nevertheless real for the patient involved (Young *et al.*, 1987).

A similar reaction in children resulted in the 'Feingold hypothesis' which attributed childhood hyperactivity (also called hyperkinetic syndrome and attention deficit disorder with hyperkinesis) to naturally occurring salicylates and by extravagant extrapolations to aspirin, tartrazine and a host of other food chemicals. The diagnosis depended on the use of exclusion diets and a subsequent challenge with substantial doses of the putative 'allergens' (Feingold, 1975). Recent studies have suggested that tartrazine at the doses employed may cause the release of histamine-like substances from human leucocytes *in vitro* but this effect does not occur at the concentrations present in foodstuffs. It is unlikely, therefore, that this effect is a primary cause of the syndrome—rather the diagnostic test produces a false positive (Murdoch *et al.*, 1987).

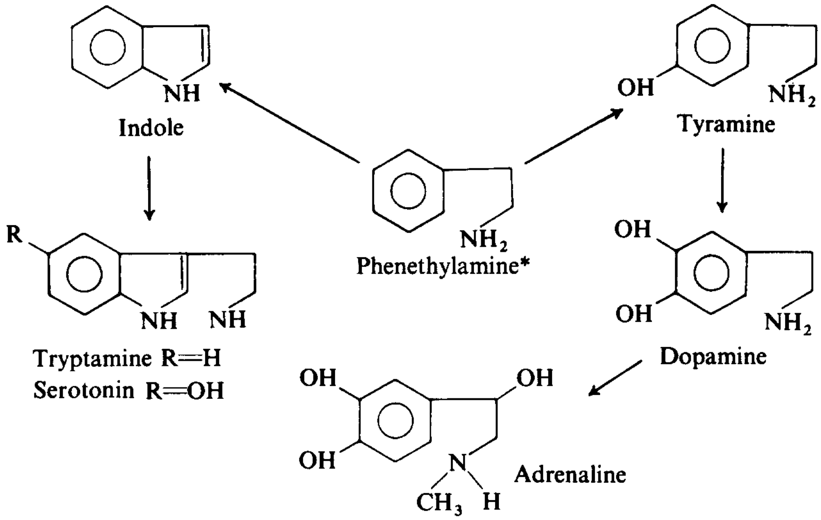
The Feingold diet, a restricted diet to exclude foods containing salicylates and a number of food additives, has proved popular with a number of parents with recalcitrant children but several objective trials of its efficiency have produced either equivocal or negative results.

The overall conclusion must be that the hyperactivity syndrome has several causes. A small minority of cases is probably due to intolerance of some component of food and this may include, in some cases,a food additive.

PHARMACOLOGICAL EFFECTS

Vasoactive amines

These are derivatives of phenethylamine synthesised in plants, especially fruits, or formed by bacterial fermentation (Fig. 1). They are recognised for their ability to induce constriction of arterioles.



* The configuration used is unconventional.

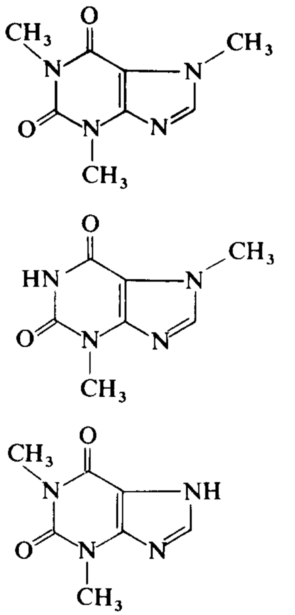
Fig. 1. The derivation of vasoactive amines.

They are capable of inducing episodic hypertension and headache, especially when their metabolism is inhibited by intercurrent therapy with monoamine oxidase inhibitors. Certain derivatives (tyramine, dopamine and adrenaline) are important neurotransmitters as are the indole derivatives tryptamine and serotonin. They are stimulants, increasing alertness and producing the signs of anxiety, a property that has been exploited pharmaceutically through the synthesis of amphetamine. They do not occur in sufficient concentration in foods derived from animals to be active but, as stated earlier, histamine certainly does in some circumstances.

An extensive range of methylated derivatives of tyramine result from bacterial fermentation and are commonly present in cheeses, beers, wines and stored meat and fish (Hoffer & Osmond, 1967).

The xanthines

The methyl xanthines, caffeine, theophylline and theobromine (Fig. 2) have long been valued for their central stimulant properties and for their therapeutic value as cardiovascular stimulants. The principal compound is caffeine, present in coffee, tea and cocoa though cocoa contains slightly more theobromine. Despite its widespread use the cardiovascular effects of caffeine are not fully elucidated. This may be because habitual users quickly become tolerant of the hypertensive action described in people unaccustomed to regular consumption. A constant effect appears to be an increase in cardiac output resulting from increased stroke-volume, or muscular contractility of the heart.



Caffeine

Theobromine

Theophylline

Fig. 2. The methylxanthines.

The behavioural effects of caffeine are also a subject of some uncertainty because of lack of precise definition of terms used, a failure to take full account of different dosages achieved by people of different weight and a failure to recognise tolerance. Where properly controlled studies have been conducted, caffeine consumption increases the rate of speaking and decreases reaction times. In children it decreases verbal memory whereas this is increased in the adult. In general the results show wide variation between individuals and the only consistent effect seems to be to counter fatigue (Dews, 1984).

PSYCHOACTIVE EFFECTS

There is a large literature on the toxicology of plant chemicals that includes several descriptions of accidental poisonings in man under special circumstances in which excessive dosage has been achieved. Given the range of toxic compounds produced it is remarkable that the incidence of poisoning is so small. This is probably because man has learned to avoid those foods that produce potent toxins and has developed his food processing ability to negate those he cannot avoid. Notwithstanding the large literature, there is still much to be learned about plant chemistry and there has been little systematic study in relation to human toxicity.

There is also a sizeable literature on the hallucinogens in edible plants though few of these plants occur in the human diet. Rather, plants exhibiting such properties are used for their effects on specific occasions such as religious rituals and ceremonies. There has been little exploration of the psychoactive effects of such compounds at less than overtly hallucinatory dosages and it remains possible that effects on mood do occur. Although many of the plants producing potent compounds have been identified, the chemistry is ubiquitous within broad limits and many other related chemical entities occur widely.

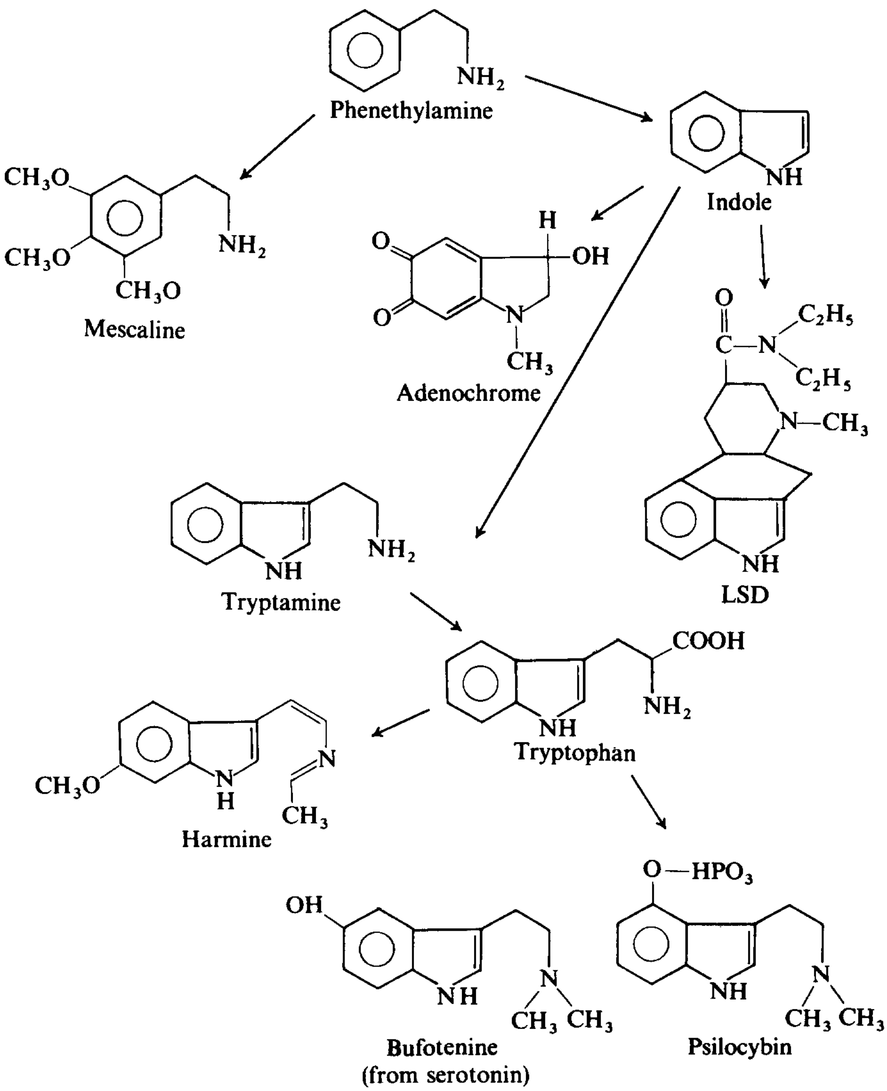


Fig. 3. Hallucinogens derived from phenethylamine.

PHENETHYLAMINE DERIVATIVES

Methoxylation of phenethylamine produces mescaline (Fig. 3), long recognised for its psychoactive properties. Deamination of mescaline results in a number of compounds (Fig. 4). Myristicin, the principal constituent of nutmeg oil, is well known to prisoners and alcoholics for its power to inebriate. Safrole, also found in nutmeg oil, has similar, though milder, effects.

Another deaminated compound is asarone and its many derivatives found in kava kava.

Indole compounds include adenochrome, tryptophan, harmine, psilocybin and bufotenine, all employed by different sects and tribes for their antidepressant or euphoric effects.

Finally, the most potent hallucinogen of all is lysergic acid diethylamide or LSD, one of a number of alkaloids derived from ergot, a common fungal infestation of rye and wheat. Ergot alkaloids are also found in ololuiqui (morning glory) long used in Central America as a narcotic (Hoffer & Osmond, 1967).

The ergot contamination of cereals is carefully controlled by law because of the toxic effects. The maximum permitted contamination of cereal for human consumption is 0·05% which theoretically could result in a daily dose of about 9 mg for someone consuming say 200 g of cereal per day (Schoch,

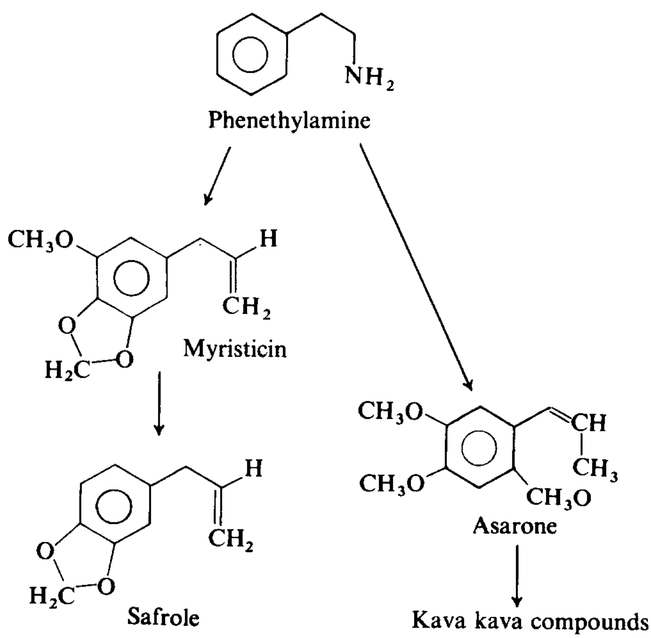


Fig. 4. Deamination products of phenethylamine.

1985). In practice the daily consumption is not likely to exceed around 100 μg of the alkaloids. It has to be recognised, however, that the minimum dose of LSD that produces detectable effects in inexperienced users is about 25 μg (Stoll, 1949).

As these fungal contaminants tend to be present mainly in bran, it is conceivable that the current fashion for wholemeal cereals could result in the consumption of enough lysergic acid derivatives to effect a lift in mood, especially when processing has been inadequate. It is also possible that the anecdotal evidence of the addictive properties of muesli biscuits should be examined more closely.

ANTICHOLINESTERASES

Many psychoactive compounds exhibit anticholinesterase activity but cholinergic compounds in general do not affect behaviour. This may need qualification in respect of central or peripheral activity. It is likely that compounds that facilitate the role of acetyl choline as a neurotransmitter *in the brain*, will have stimulant or depressive effects with associated hallucination. For example, the α-glycosides in the potato, solanine and chaconine, have such activity and there is evidence that chaconine achieves moderate concentrations in the brain (Alozie *et al.*, 1979). It has yet to be demonstrated whether this compound affects behaviour.

The classic cholinergics, atropine and scopolamine, are well known for central effects though these have been studied more from the toxicological aspects. Certain derivatives, however, have found widespread use in psychiatric medicine.

DISCUSSION

Consideration of the behavioural effects of food is handicapped by the inability, as yet, to disentangle the multiplicity of subtle changes which together constitute observable changes on behaviour patterns. Studies to date, have, of necessity, concentrated on the gross aberrations induced by the large doses of compounds selected, usually by a kind of folk lore tuned by centuries of trial, for one particular attribute. The attributes most sought are stimulatory, depressant or hallucinatory but it is well recognised that any one compound may produce the gamut of changes depending on dose, time and the receptivity of the subject. Studies on small dosages fail because of the insensitivity of methods to measure changes and a dependence on subjective impressions.

It is certain that the human diet contains many compounds that could affect brain activity even after the food has been subjected to processes such as cooking. It is equally certain that none of these compounds occurs at concentrations likely to produce obvious changes. But it cannot be excluded that the concentrations achieved may effect subtle changes in mood or attention that have major influences on food choice and social intercourse. It is also possible that individuals attempt to control their moods by their selection of food. The exploration of the relationship between taste, clearly a major determinant of food preference, and the sense of pleasure and well-being induced by food is in its infancy and there is much to learn. A recent suggestion that the ingestion of sucrose brings about the release of endogenous opioids in the brain may prove to have profound significance, opening up, as it does, the concept that food chemicals need not necessarily possess psychoactive properties in themselves (Blass, 1987). It also points, for the first time, to a mechanism that may underlie all of the enjoyment obtained from gourmet delights.

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