

Intense Sweeteners, Food Intake, and the Weight of a Body of Evidence

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Received 25 March 1993

RENWICK, A. G. *Intense sweeteners, food intake and the weight of a body of evidence*. *PHYSIOL BEHAV* 55(1) 139-143, 1994.-A review of published data shows that although intense sweeteners have been shown to increase hunger ratings in some studies in humans, this has not been a consistent and reproducible observation. Any slight effect on perceived hunger has not been translated into an increase in food ingestion or effects on blood concentrations of insulin or glucose. Studies on the covert substitution of caloric sweeteners by intense sweeteners have shown either a decrease or no change in body weight. The published database does not support the concept that the consumption of intense sweeteners results in a paradoxical increase in calorie intake and body weight.

Intense sweeteners	Acesulfame-K	Aspartame	Cyclamate	Saccharin	Hunger	Appetite
Calorie intake	Insulin	Weight				

QUESTIONS about the potential benefits of intense sweeteners (also referred to as nonnutritive or artificial sweeteners) arose largely from only two articles, both of which were published in 1986. These articles suggested the possibility that the consumption of intense sweeteners, such as aspartame and saccharin, could increase hunger ratings and, therefore, would result in a higher food intake and an increase in body weight. This situation would be the very opposite of that which common sense dictates and it is not surprising that it attracted considerable media attention-it is a classic example of the "man bites dog" type of story. Neither article demonstrated that the use of intense sweeteners actually caused an increase in calorie intake, and both had important limitations with respect to drawing such a conclusion.

Since 1986 a large number of studies have shown that these early articles led to premature and incorrect conclusions and that the use of intense sweeteners does not cause an increase in calorie intake or body weight. Despite the publication of this large amount of more recent research in proper peer-reviewed journals, the media have not updated their story and continue to misinform the public based on outdated information.

The following review provides a brief summary of the main findings and limitations of the two original articles followed by a resumé of the more recent investigations in human volunteers. It is clear from the recent data that the use of intense sweeteners does not cause an increase in food intake or body weight. It is also clear that intense sweeteners can help to reduce calorie intake in individuals who are trying to control their weights.

It should be appreciated that intense sweeteners are not medicines that suppress appetite and that they will only help to reduce body weight if the sugar calories replaced in one food or drink item are not subsequently taken in by the increased consumption of something else. However, if an intense sweetener is used to replace sugar in an item, such as a drink, then it is possible for the individual

to use the calories saved to enjoy another product. Such an approach will not result in weight loss, but may help to prevent an increase in weight while allowing the consumer to have a wider choice of foods within a balanced diet.

THE ORIGINAL ARTICLES

The article by Blundell and Hill (5) was a brief letter to *The Lancet* in which hunger ratings were reported after the consumption of water or water containing either glucose or aspartame. As expected, the consumption of the glucose-sweetened drink, which gave an intake of 185 kcal, resulted in the suppression of appetite. Unexpectedly, the aspartame-sweetened drink was reported to give increased hunger ratings compared to water. It was suggested that the sweet taste gave a residual hunger that the authors claimed, on the basis of unpublished studies, to result in an increased food consumption. However, no data were presented to substantiate this claim, which has not been supported by later studies (see below). Thus, this paper did not in itself demonstrate that the consumption of intense sweeteners resulted in a subsequent increase in food intake but represents an interesting observation that was worthy of subsequent more thorough investigation.

The other article was published at about the same time by American researchers (36) who were analysing the vast database on 1 million American men and women being developed by the American Cancer Society. The database was not set up to assess factors influencing body weight, and the results that were extracted from the database were based on the individuals' memory of their body weights 1 year previously. In addition, the study considered data for 1978 when only saccharin was available and restricted the study group to women aged 50-69 who had not changed their diets in such a way that it might affect body weight, i.e., they excluded anyone who may have used intense sweeteners as part of a calorie-controlled diet. Comparison of users and nonusers of intense sweeteners showed that the users had gained more weight over the 12 months than nonusers. This finding appeared to support the study by Blundell and Hill (5) above, and was interpreted by the media as showing that intense sweeteners make you put on weight. In reality, the study is flawed scientifically because the subjects obviously decided for themselves whether or not to use intense sweeteners. Simple logic dictates that individuals who had experienced difficulty in controlling their weights would be more likely to take intense sweeteners, while people who had a stable body weight would be less likely to consume intense sweeteners. In consequence, the authors were not comparing two similar populations, and it is not possible to conclude that the intake of sweeteners was responsible for the increase in weight; indeed, the increase in weight was possibly the cause for the decision to take intense sweeteners! An interesting observation in the most obese groups in this study was that a high weight loss (> 10 pounds) occurred more frequently in those who used intense sweeteners.

THE RESULTS OF MORE RECENT STUDIES

In this review only results in humans are considered because the questions relate to the patterns of human food consumption following the ingestion of intense sweeteners. Data from animal studies may be useful in cases where appropriate investigations cannot be undertaken in humans, but for subjective effects, such as perception of hunger, only human data are of real relevance. In addition, this review has been restricted to papers that have published in peer-reviewed journals and does not include anecdotal findings or unsubstantiated case reports. The large recent database of well-conducted investigations, many of which were double-blind and placebo controlled, provides the proper basis for assessing any possible effect of intense sweeteners on hunger, food intake, and weight control. The relevant findings have been subdivided into four tables relating to:

1. Do intense sweeteners increase perceived hunger?
2. Do intense sweeteners increase food intake?
3. Do intense sweeteners affect insulin release and the control of blood glucose concentrations?
4. Do intense sweeteners help in weight control when consumed regularly?

Table 1

HUNGER RATINGS FOLLOWING SINGLE DOSES OF INTENSE SWEETENERS

Sweetener	Vehicle	Time after		Hunger Rating	Reference
		n	Dose		
AceK	Water	12	60 min	↔	28
ASP	Water	12	60 min	↑	28
ASP	Water	27	60 min	↔	29
ASP	Water	95	40-60 min	↑	5
ASP	Drink	20	90 min	↔	1*
ASP	Drink	20	60 min	↔	4
ASP	Drink	42	30, 60 min	↔	33
ASP	Dessert	32	up to 120 min	↔	32
ASP	Gum	120	30-90 min	↑	38
ASP	Capsules	26	105 min	↔	34
ASP	Capsules	27	60 min	↓	29
ASP	Capsules	16	60 min	↔	30
SACC	Water	12	60 min	↔	28
SACC + ASP	Drink	20	30-60 min	↔	8
SACC	Yogurt	24	60 min	↑	27

AceK = acesulfame-K; ASP = aspartame; SACC = saccharin.

n = Number of subjects.

↔ = No difference compared with placebo; ↑ = increased compared with placebo; ↓ = decreased compared with placebo.

* This study compared aspartame with cyclamate, not with an unsweetened drink.

Do Intense Sweeteners Increase Perceived hunger?

In the analyses in Table 1, the effects of the intense sweetener are compared with an unsweetened control material and not with the comparable material sweetened with sugar. Therefore, the lack of an increase in hunger with the intense sweetener suggests that there would be a net saving in calorie intake compared with the conventional product. This conclusion is supported by the results discussed below (see Table 4).

It is clear from the data in Table 1 that the report by Blundell and Hill (5) has not been substantiated by later studies. Only three subsequent studies have reported a subjective increase in hunger ratings; two by Blundell and colleagues—one with saccharin in yogurt (27) and the other essentially a repeat of their earlier study (28)—and a study by Tordoff and Alleva (38) who maximised stimulation of sweet-taste receptors by incorporating different concentrations of aspartame into chewing gum. The discrepancy between the studies may be due, in part, to the artificial nature of the original test solution in which the sweeteners were added to water and no other taste component was present so that the drink was not representative of normally available products. The study by Tordoff and Alleva also used a single taste in the chewing gum, and these authors suggested that a number of variables could alter the influence of intense sweeteners on hunger ratings and that any observed increase due to the sweetener was a fragile phenomenon.

Do Intense Sweeteners Increase Food Intake?

A number of studies have extended the single dose trials on hunger ratings, as outlined above, to measure actual food intakes at a set time after the test dose of the intense sweetener. In only one of these (Table 2) has there been a greater calorie intake following the sweetener compared with water or the control vehicle. Therefore, it is clear that if intense sweeteners do result in a fragile, residual hunger, then this does not cause an increase in calorie intake. In consequence, there is no scientifically credible basis for the continuing suggestions in the media that intense sweeteners make you eat more or cause an increase in body weight. This conclusion is supported by data from studies on continuous intake as discussed below.

A recent paper (20) in which yogurt containing five different concentrations of aspartame was given to 11 men and 10 women has been interpreted in the French media as proving that intense sweeteners increase food intake. In this study, the two lowest concentrations of aspartame were rated more pleasant than higher concentrations and were associated with higher calorie intakes over the following 14 h. However, there was no placebo in this study and the only suggestion that an increase in concentration of aspartame increased calorie intake was a slightly and nonsignificantly greater calorie intake between the two lowest concentrations in men but not women. For all other comparisons an increase in concentration of the sweetener decreased the subsequent calorie intake. Interpretation of the findings as showing that intense sweeteners increase calorie intake is not justifiable, and is not consistent with a subsequent study by the same group (11) or with other studies listed in Table 2.

Table 2

FOOD INTAKE FOLLOWING SINGLE DOSES OF INTENSE SWEETENERS

Sweetener	Vehicle	Time after		Hunger Rating	Reference
		n	Dose		
AceK	Water	12	65 min	↔	28
ASP	Water	12	65 min	↔	28
ASP	Water	27	60 min	↔	29
ASP	Water	24	38 min	↔	26
ASP	Drink	20	90 min	↔	1*
ASP	Drink	20	60 min	↔	4
ASP	Drink	24	0, 30, 60 min	↓ or ↔	3
ASP	Drink	106	60 min	↔	6
ASP	Drink	42	30,60 min	↔	33
ASP	Dessert	32	120 min	↔	32
ASP	Cheese	24	3, 5.5, 9.5 h	↔	11
ASP	Capsules	26	105 min	↔	34
ASP	Capsules	27	60 min	↓	29
ASP	Capsules	16	60 min	↓	30
SACC	Water	12	65 min	↔	28
SACC + ASP	Drink	20	60 min	↔	8
SACC	Yogurt	24	60 min	↑	27

AceK = acesulfame-K; ASP = aspartame; SACC = saccharin.

n = Number of subjects.

↔ = No difference compared with placebo; ↑ = increased compared with placebo; ↓ = decreased compared with placebo.

* This study compared aspartame with cyclamate, not with an unsweetened drink.

Do Intense Sweeteners Affect Insulin Release and the Control of Blood Glucose Concentrations?

The ingestion of food causes the release of insulin which results in the absorbed glucose being transferred from the blood into tissues. The release of insulin occurs in two phases. The cephalic or preabsorption phase occurs about 5 min after the ingestion of food, precedes the absorption of glucose, is a minor and variable response (37), and is caused by the organoleptic properties of the food, i.e., its taste, smell, and texture. The postprandial phase occurs later, after about 15 min, is the major phase of insulin release, and is related to absorbed glucose or to amino acids which may also trigger insulin release.

The question of a possible effect of intense sweeteners on this system has been raised because it could provide a scientifically credible rationale for the proposed effects on hunger. If intense sweeteners stimulated insulin release this would cause a decrease in blood glucose concentrations and thereby stimulate appetite. This suggestion was largely hypothetical with some support from animal studies. Investigations undertaken in humans are summarised in Table 3. Only one study has demonstrated a cephalic phase insulin response accompanied by a decrease in blood glucose. However, this study involved the administration of an aspartame-sweetened strawberry-flavoured dessert and, therefore, the response detected may not have been related to the sweetener. An insulin response was not

detected in other studies using a simple solution of aspartame, although in many of these the blood sampling times were too late to detect the minor early cephalic phase. This criticism does not apply to a recent study (13), which found no effect of four different intense sweeteners on plasma insulin or blood glucose concentrations. What is very clear from all of these studies is that intense sweeteners do not significantly affect blood glucose levels so that there would not be this physiological stimulus for an increase in perceived hunger.

Table 3

EFFECTS OF INTENSE SWEETENERS ON INSULIN AND BLOOD GLUCOSE CONCENTRATIONS

Sweetener	Vehicle	n	Insulin Concentration	Glucose Concentration	Reference
Healthy Subjects					
AceK	Water	14	↔	↔	13
ASP	Water	17	↔	↔	7
ASP	Water	16	↔	↔	9
ASP	Water	7	↔	↔	21
ASP	Water	24	↔	↔	26
ASP	Water	14	↔	↔	13
ASP	Drink	12	↑	↔	14
ASP	Dessert	20	↑	↓	37
ASP	Capsule	16	↔	↔	9
CHS	Water	14	↔	↔	13
SACC	Water	14	↔	↔	13
SACC	Drink	12	↔	↔	14
Diabetic Patients					
ASP	Water	22	↔	↔	21
ASP	Water	26	↔	↔	35
ASP	Drink	10	↔	↔	14
SACC	Drink	10	↔	↔	14

AceK = acesulfame-K; ASP = aspartame; CHS = cyclamate; SACC = saccharin.

n = Number of subjects.

↔ = No difference compared with placebo; ↑ = increased compared with placebo; ↓ = decreased compared with placebo.

Do Intense Sweeteners Help in Weight Control When Consumed Regularly?

A recent study (10) compared food intakes in users and non users of intense sweeteners by a 24-h dietary recall. The results suggested that consumption of intense sweeteners resulted in a produced intake of sugars in women but an increase in men; but this study has the same basic flaw of self-selected groups that was present in the study of Stellan and Garfinkel (36). A similar criticism applies to the earlier study (22) which found a reduced calorie intake in college students who chose to use intense sweeteners. To avoid such a bias in the basic study design and to produce scientifically credible results it is important that the subjects are unaware of the substitution of sucrose by an intense sweetener.

During continuous feeding studies in humans it is possible to replace the sugar in soft drinks with either an intense sweetener or nothing. Such a study has been reported recently in which volunteers were given a large amount of soda sweetened with high fructose corn syrup or aspartame or no experimental drinks for periods of 3 weeks (39) (Table 4). There were significant decreases in calorie intake and in body weight when the subjects drank the aspartame soda compared with when they had no extra drink, which is the opposite of what would be expected if intense sweeteners increased appetite.

Table 4

**FOOD INTAKE AND BODY WEIGHTS FOLLOWING CHRONIC INTAKES
OF INTENSE SWEETENERS**

Sweetener	Vehicle	n	Duration of Study	Effect	Reference
ASP	Sodas	30	3 weeks	↓ kcals	39
ASP	Sodas	30	3 weeks	↓ weight	39
ASP	Cereal	24	4 weeks	↔ weight	19
ASP	Diet	8	6 days	↓ kcals	23
ASP	Diet	6	12 days	↓ kcals	24
ASP	Diet	13	12 days	↓ kcals	25
ASP	Capsules	108	24 weeks	↔ weight	18
CHS-SACC	Diet	25	41 days	↓ weight	2

ASP = aspartame; CHS = cyclamate; SACC = saccharin.

n = Number of subjects.

↔ = No difference compared with placebo; ↑ = increased compared with placebo; ↓ = decreased compared with placebo.

Note: the studies were run under blind or covert conditions so that subjects were unaware of the dietary manipulation or which product was sweetened with an intense sweetener or a sugar.

Obviously it is not possible to replace food continuously with no calories, but a number of studies have replaced some items of the diet with low calorie equivalents without the individual being aware of the substitution. Under such circumstances there was usually a decrease in total calorie intake (Table 4), although this may not be sustained. Again, the decrease in calories is the opposite of what would be expected if intense sweeteners enhanced appetite and food intake. The calorie intakes in these covert replacement studies sometimes showed an initial rapid decrease which tended to revert towards normal. This indicates that people may be unlikely to lose weight just by using intense sweeteners without control of their total calorie intake.

Studies in subjects on weight control programs have shown that intense sweeteners can be helpful in making their regimen both more acceptable and successful (12,15-17).

CONCLUSIONS

It is clear that recent comprehensive studies [reviewed in (31)] have disproved the early reports that consumption of intense sweeteners may increase appetite and food intake compared with water or an unsweetened product. In reality, of course, intense sweeteners replace sugar and, therefore, there has to be a net saving in calories compared with the normal product itself. Some individuals may choose to use the lost calories to assist in weight reduction; others may choose to use the lost calories to allow them to enjoy some other item of food. In both cases there is a benefit to the consumer by allowing them a wider choice without an extra intake of calories.

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