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Identification of gases responsible for the odour of human flatus and evaluation of a device purported to reduce this odour

F L Suarez, J Springfield, M D Levitt

Abstract

Background/Aims—While the social significance of flatus derives mainly from its odour, previous studies have focused on the non-odoriferous components of rectal gas. The aims of the present study were to determine the role of sulphur-containing gases in flatus odour and test the efficacy of a device purported to reduce this odour.

Methods—Flatus was quantitatively collected via rectal tube from 16 healthy subjects who ingested pinto beans and lactulose to enhance flatus output. The concentrations of sulphur-containing gases in each passage were correlated with odour intensity assessed by two judges. Odour intensity was also determined after treatment of flatus samples with zinc acetate, which binds sulphhydryl compounds (hydrogen sulphide and methanethiol), or activated charcoal. Utilising gas-tight Mylar pantaloons, the ability of a charcoal lined cushion to adsorb sulphur-containing gases instilled at the anus of eight subjects was assessed.

Results—The main sulphur-containing flatus component was hydrogen sulphide (1.06 (0.2) $\mu\text{mol/l}$), followed by methanethiol (0.21 (0.04) $\mu\text{mol/l}$) and dimethyl sulphide (0.08 (0.01) $\mu\text{mol/l}$) (means (SEM)). Malodour significantly correlated with hydrogen sulphide concentration ($p \leq 0.001$). Zinc acetate reduced sulphur gas content but did not totally eliminate odour, while activated charcoal removed virtually all odour. The cushion adsorbed more than 90% of the sulphur gases.

Conclusion—Sulphur-containing gases are the major, but not the only, malodorous components of human flatus. The charcoal lined cushion effectively limits the escape of these sulphur-containing gases into the environment.

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Keywords: flatus; odour; sulphur containing gas; hydrogen sulphide; charcoal

Rectal gas has been a topic of scientific and scatological interest since the beginning of recorded history. This fascination with flatus has little to do with its volume, 200–2500 ml per day,^{1,2} but rather its offensive odour. Nevertheless, virtually all scientific publications concerning flatus, which date back to 1816,³ have focused on the quantitatively important, but non-odoriferous components

(oxygen, nitrogen, carbon dioxide, hydrogen, and methane).¹⁻⁵ The odour results from trace components that have proved difficult to identify and quantify.

The most rigorous study of odoriferous faecal compounds involved the gas chromatographic-mass spectroscopic analysis of gases produced by human faeces. Sulphur-containing compounds (methanethiol, dimethyl disulphide, and dimethyl trisulphide) were felt to be responsible for the unpleasant odour.⁶ In addition, several reports have utilised non-quantitative techniques in the study of sulphur-containing gases in flatus.^{3,7} However, there has been no systematic, quantitative study of the excretion of sulphur-containing gases in flatus. The goals of the present study were to identify and quantify the sulphur-containing gases in human flatus, determine to what extent these gases account for the offensive odour, and evaluate the efficacy of a device that is being marketed as a remedy for excessively noxious flatus.

Materials and methods

STUDIES OF FLATUS

Subjects

Flatus samples were obtained from 16 healthy subjects (six women and 10 men, age 18–47 years) with no history of gastrointestinal disease or antibiotic ingestion during the preceding three months. The protocol was approved by the Human Subjects Committee of the Minneapolis Veterans Affairs Medical Center.

Diet

To ensure flatus output, the diet of the subjects was usually supplemented with 200 g pinto beans on the night before and the morning of the study, plus 15 g lactulose two hours before gas collection. Flatus samples were collected from three subjects while they were on a non-supplemented diet.

Flatus collection system

Flatus was collected via a rectal tube (Davol, Cranston, Rhode Island, USA) connected to a gas impermeable bag (Quintron, Milwaukee, Wisconsin, USA). Preliminary studies showed that the anus makes a gas tight seal with a rectal tube, provided that the tube is patent. Each passage was collected in a separate bag, and volume was determined by aspiration into a calibrated syringe.

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Table 1 Volume, sulphur containing gas content, and odour intensity of individual flatus passages

Source of sample	Total volume per passage (ml)	Sulphur containing gases								Odour intensity	
		<i>H₂S</i>		MES		DMS		Total		Judge 1	Judge 2
		Concentration (μmol/l)	Volume (μl)	Concentration (μmol/l)	Volume (μl)	Concentration (μmol/l)	Volume (μl)	Concentration (μmol/l)	Volume (μl)		
All subjects	107 (8.1)	1.06 (0.20)	3.12 (0.74)	0.21 (0.04)	0.59 (0.11)	0.08 (0.01)	0.22 (0.04)	1.35 (0.23)	3.93 (0.84)	3.3 (0.3)	5.6 (0.3)
Men (n=10)	119 (11.9)	0.59 (0.14)	2.30 (0.75)	0.19 (0.04)	0.63 (0.15)	0.08 (0.01)	0.22 (0.04)	0.86 (0.16)	3.16 (0.86)	2.8 (0.3)	5.1 (0.4)
Women (n=6)	88 (8.9)	1.77 (0.43)	4.33 (1.55)	0.24 (0.05)	0.54 (0.17)	0.07 (0.02)	0.22 (0.04)	2.08 (0.49)	5.06 (1.66)	4.2 (0.6)	6.7 (0.4)
Gender difference (p value)	0.055	0.003	0.180	0.438	0.666	0.878	0.789	0.007	0.269	0.019	0.016

Data are expressed as mean (SEM) (n=87 total passages, n=52 passages in men, and n=35 passages in women).

Odour intensity was rated on a linear scale ranging from 0 (no odour) to 8 (very offensive).

MES, methanethiol; DMS, dimethyl sulphide.

Identification of sulphur gases and assessment of recovery

Initially, the identity of the sulphur-containing gases was established via gas chromatographic-mass spectroscopic analysis, and, subsequently, by characteristic gas chromatographic retention times. Preliminary studies showed that the sulphur-containing gases, particularly hydrogen sulphide, rapidly reacted with glass, some plastics, and rubber, but were stable in polypropylene syringes (subsequently used for all gas transfers). Sulphur-containing gases infused through the rectal tube into the bag were completely recovered.

Organoleptic (odour intensity) assessment

The odour of flatus was rated by two judges who showed in preliminary studies that they had the ability to identify a variety of odours and to differentiate between the odours of the major sulphur-containing gases. In a blinded study, both judges showed their ability to identify correctly threefold differences in concentrations of the sulphur-containing gases over a concentration range of 0.022–0.45 mmol/l. In the studies of flatus odour, two 20 ml syringes were blindly and randomly presented to each judge; one contained 10 ml flatus and the other 10 ml atmosphere. In an odour free environment, the judges held the syringe 3 cm from their noses and slowly ejected the gas, taking several sniffs.⁸ Odour was rated on a linear scale from 0 ("no odour") to 8 ("very offensive"). After 20 seconds, this procedure was repeated with the other sample.

Zinc acetate and activated charcoal treatments

Zinc reacts with hydrogen sulphide and methanethiol whereas activated charcoal adsorbs many additional odoriferous compounds. Aliquots (20 ml) of flatus were mixed with 3 ml of a 15% zinc acetate solution at 37°C for five minutes or were passed through a 5 cm × 0.5 cm column containing activated charcoal. The

odours of the untreated and treated samples were compared as described above.

EVALUATION OF A CHARCOAL-CONTAINING CUSHION

Collection system

Eight subjects wore gas tight pantaloons fashioned of metalised nylon-low density polyethylene (Mylar; Anagram International Inc., Minneapolis, Minnesota, USA) which were sealed to the skin at the waist and thighs with duct tape. Studies of subjects submerged in water showed no leakage from the pants, and gas instilled into the pants was completely recovered. The pantaloons were equipped with two ports. The inner aspect of one port was attached to a catheter that could be positioned at the anus.

Cushion assessment

The ability of a commercially available device (Toot Trapper; UltraTech Products Inc., Houston, Texas, USA) to reduce flatus odour was tested. This device consists of a fabric covered polyurethane foam cushion (43.5 × 38 × 2.5 cm), one surface of which is coated with activated charcoal. In addition, an identical appearing "placebo" cushion (with the charcoal encased in Mylar) was used. One of the two cushions or no cushion was placed in the pantaloons. The end of the infusion tube was placed (inside the underwear) at the anus as the subject sat on the cushion (if a cushion were being tested). A 200 ml sample of gas containing 1.8 mmol/l hydrogen sulphide, methanethiol, and dimethyl sulphide was instilled at the anus over five seconds, and 5 ml ethane was instilled into the pantaloons via the second port to provide a dilutional indicator of total gas volume. After 60 seconds, gas in the pantaloons was mixed by palpation, and a sample was obtained for analysis. The pants were flushed, and, in random order, the above procedure was repeated for the other treatments.

Analytical techniques

Measurements were obtained using an HP 5890A gas chromatograph (Hewlett-Packard Co., Palo Alto, California, USA) equipped with a flame photometric detector specific for sulphur-containing compounds, and a flame ionisation detector for ethane. For sulphur gas measurements, a 1.0 ml gas sample was injected on to a Teflon column (2.4 m, 3.1 mm outer diameter packed with Chromosil 330

Table 2 Correlation between the concentration of sulphur containing gases and odour intensity of flatus passages

Odour intensity	<i>H₂S</i>	MES	DMS	Total sulphur-containing gases
Judge 1	r = 0.644 p < 0.001	r = 0.248 p = 0.071	r = 0.333 p = 0.014	r = 0.628 p < 0.001
Judge 2	r = 0.437 p = 0.001	r = 0.304 p = 0.026	r = 0.227 p = 0.099	r = 0.444 p = 0.001

Data were analysed using the Pearson correlation coefficient. N=54 flatus passages.

Odour intensity was rated on a linear scale ranging from 0 (no odour) to 8 (very offensive).

MES, methanethiol; DMS, dimethyl sulphide.

Table 3 Effect of activated charcoal and zinc acetate on the concentration of sulphur containing gases and odour intensity of flatus passages

Treatment	H_2S (nmol/l)	MES (nmol/l)	DMS (nmol/l)	Odour intensity	
				Judge 1	Judge 2
None	1365 (566)	445 (111)	80.1 (13.5)	4.1 (0.7)	6.5 (0.5)
Activated charcoal	4.5 (1.8) p = 0.03	1.8 (0.5) p = 0.001	0.9 (0.5) p > 0.001	0.1 (0.1) p > 0.001	0.4 (0.1) p = 0.001
None	526 (144)	189 (38.2)	29.3 (3.6)	2.5 (0.5)	5.8 (0.5)
Zinc acetate	17.1 (4.9) p = 0.01	16.7 (4.1) p > 0.001	18.5 (3.15) p = 0.04	0.7 (0.2) p = 0.004	3.4 (0.6) p = 0.007

Data were analysed using analysis of variance (ANOVA) and are expressed as mean (SEM). N = 9 and 16 flatus passages for charcoal treatment and zinc acetate respectively.

Odour intensity was rated on a linear scale ranging from 0 (no odour) to 8 (very offensive).

MES, methanethiol; DMS, dimethyl sulphide.

(Supelco, Bellefonte, Pennsylvania, USA)) maintained at 65°C. The carrier gas was nitrogen (15 ml/min). Ethane was assayed using a molecular sieve column (1.05 m, 3.1 mm outer diameter, 5A packing), an oven temperature of 100°C, and nitrogen as the carrier gas (40 ml/min). Concentrations were determined from comparison with known concentrations of authentic gases.

DATA ANALYSIS

Data are expressed as mean (SEM). The concentration of each sulphur-containing gas as well as the sum of these compounds was correlated with odour intensity using the Pearson correlation coefficient. A *t* test was used to compare the results from women and men and the effect of the treatments (zinc acetate and activated charcoal). The effectiveness of the cushion was assessed by one way analysis of variance. To characterise individual group differences across treatments, post-hoc Fisher's LSD was performed.^{9 10}

Results

STUDIES OF FLATUS

Table 1 summarises the results of the flatus analyses in subjects ingesting the supplemented diet. Subjects passed three to nine samples during the four hour test period. The volume of individual flatus samples averaged 107 (8.1) ml.

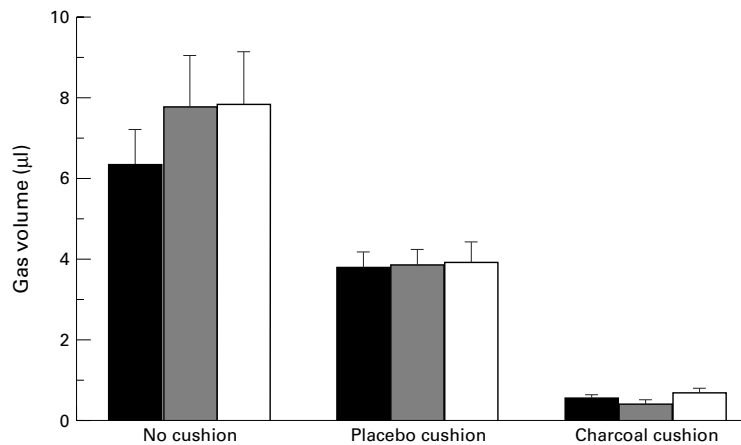


Figure 1 Volumes of the sulphur-containing gases escaping into the environment of the gas tight pantaloons when gas was instilled at the anus in the presence of the activated charcoal cushion, placebo cushion, or no cushion. Values for hydrogen sulphide (black columns), methanethiol (shaded columns), and dimethyl sulphide (white columns) are shown as mean (SEM) from a total of 58 instillations in eight subjects. Analysis of variance showed that the three treatments differed from each other at $p < 0.01$.

The major sulphur-containing gas was usually hydrogen sulphide, followed by methanethiol and dimethyl sulphide. In 22% of samples, methanethiol concentration exceeded that of hydrogen sulphide. Other sulphur gases were present in such low concentrations that identification was precluded. Similar results were observed for 13 flatus samples obtained from three subjects eating their usual non-supplemented diet (data not shown).

The sum of the concentrations of the sulphur-containing gases significantly correlated with odour intensity (table 2). Hydrogen sulphide showed the strongest correlation, followed by methanethiol and dimethyl sulphide. The odour intensity of the atmospheric samples averaged 0.16 (0.05). To determine if the sulphur-containing gases in flatus produce a noxious odour, authentic standards were mixed in concentrations simulating the mean composition of human flatus: hydrogen sulphide, 0.90 mmol/l; methanethiol, 0.36 mmol/l; and dimethyl sulphide, 0.18 mmol/l. Both judges deemed the gas mixture to have a distinctly objectionable odour resembling that of flatus. When the three gases were presented individually to the judges, the odours of hydrogen sulphide, methanethiol, and dimethyl sulphide were respectively described as "rotten eggs", "decomposing vegetables", and "sweet". Mixtures containing varying concentrations of hydrogen sulphide and methanethiol had distinctly different odours.

Treatment with activated charcoal eliminated virtually all of the sulphur containing gases and odour. Treatment with zinc acetate also markedly reduced the concentrations of hydrogen sulphide and methanethiol and reduced, but did not eliminate, offensive odour (table 3).

Table 1 compares the flatus of men and women. The flatus of women had a significantly higher concentration of hydrogen sulphide ($p < 0.01$) and a greater odour intensity ($p < 0.02$) than did that of men. However, men tended to pass higher volumes of gas than did women ($p = 0.055$). As a result, the volume of sulphur gases in each passage did not differ between men and women.

EVALUATION OF EFFICACY OF THE CHARCOAL-CONTAINING CUSHION

As shown in fig 1, the use of the charcoal cushion decreased the volume of each of the sulphur gases to about 9% of that observed with no cushion ($p < 0.01$) and to about 20% of that with the placebo cushion ($p < 0.01$).

Discussion

For many years, aromatic breakdown products of amino acids such as indole and skatole were believed to be the primary malodorous compounds in flatus.¹¹⁻¹³ However, Moore *et al*⁶ found that minimal quantities of indole and skatole were released from human faeces, and that these compounds had an odour distinctly different from that of human faeces. They concluded that organic sulphides of bacterial origin, primarily methanethiol, dimethyl disulphide, and dimethyl trisulphide, were the primary malodorous compounds elaborated by faeces.⁶

In contrast, our analyses of human flatus showed that hydrogen sulphide, methanethiol, and dimethyl sulphide were present in much higher concentrations than were the other sulphur-containing gases. Each of these compounds are gases at physiological temperature (boiling point <38°C). Our failure to detect appreciable concentrations of dimethyl disulphide and dimethyl trisulphide in flatus probably reflects the low volatility of these compounds (boiling points >100°C).

Determination of the quality and intensity of an odour requires the human nose (and brain) to serve as an arbiter, the so called organoleptic technique.¹⁴ We found a highly significant positive correlation between the odour intensity of flatus samples and the sum of the sulphur-containing gases. In addition, an "artificial" flatus sample containing physiological concentrations of hydrogen sulphide, methanethiol, and dimethyl sulphide had an unpleasant odour reminiscent of rectal gas. Since hydrogen sulphide was the predominant sulphur gas in 78% of samples and the concentration of this gas had the strongest correlation with odour, it seems likely that hydrogen sulphide was the most important determinant of flatus odour. It should be noted that flatulence was stimulated in our subjects via the feeding of a diet rich in pinto beans. It is possible that a diet containing some other source of non-absorbable fermentable material would have resulted in other malodorous compounds.

Hydrogen sulphide and methanethiol have dissimilar disagreeable odours, whereas dimethyl sulphide has a "sweet" smell and probably plays little part in flatus malodour. Studies with gas mixtures containing different relative concentrations of hydrogen sulphide and methanethiol suggested that variable concentrations of these gases may account for differences in olfactory quality of individual flatus samples.

Further evidence of the importance of hydrogen sulphide and methanethiol to flatus odour was provided by studies showing that treatment of samples with zinc acetate, which rather specifically binds these sulphhydryl compounds, markedly reduced odour. However, the persistence of unpleasant odour in some samples suggests a role for volatiles in addition to these two gases. Treatment with activated charcoal virtually eliminated the offensive odour of all samples.

The anecdotal belief that men tend to produce more objectionable flatus than women was not supported by our limited number of observations in a very small group of subjects. Although highly variable, the flatus of women had a significantly greater concentration of hydrogen sulphide and was deemed to have a significantly worse odour by both judges. However, in practice, the ability of malodorous flatus to stimulate the nose is a function of the volume (as opposed to the concentration) of noxious gases in an individual passage. Because men tended to have greater volumes of gas per passage, no significant gender differences were observed for sulphur gas volume per passage.

Hydrogen sulphide is a product of the metabolism of sulphate-reducing bacteria, organisms that utilise sulphate as a receptor for electrons generated during the dissimilation of hydrogen or low molecular mass organic substrates.^{15 16} The sulphur for these reactions may be derived from mucin or dietary sources. Thus production of these gases could potentially be reduced via manipulations that alter the colonic flora or the colonic availability of sulphur or dissimilatory substrates. Sulphate, which is poorly absorbed in the small bowel, is naturally present in cruciferous vegetables (cabbage, broccoli) and nuts and as an additive in bread and beer.¹⁷ Another major dietary source is sulphur-containing amino acids (methionine, cysteine) present in protein. However, these proteins must be incompletely absorbed in the small bowel if they are to serve as a source of sulphur for the colonic bacteria.

The demonstration that activated charcoal and zinc remove sulphur gases and eliminate the offensive odour of flatus suggests that these products, used either internally or externally (around the anus), could have therapeutic potential for individuals suffering from excessively offensive rectal gas. The only commercially available product purported to reduce flatus odour is a charcoal-containing cushion. Objective testing of the efficacy of this device requires reproducible measurements of the volume of sulphur gases that escape past the cushion into the local environment. To this end, we fabricated gas tight Mylar pantaloons into which were inserted the active cushion, an identical appearing placebo cushion, or no cushion. After instillation of the sulphur gases at the anus, measurements of the gas space of the pantaloons showed that the active cushion reduced the sulphur gas concentration by about 11-fold as compared with no cushion and by about 6-fold as compared with the placebo cushion. Although effective, the charcoal cushion is unwieldy. Less cumbersome absorptive devices could be developed, and the efficacy of such devices could be readily tested using the methodology described in the present study.

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