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THE EFFECT OF CAPSAICIN ON THE SMALL INTESTINAL ABSORPTION OF GLUCOSE AND ALANINE IN THE RAT

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Abstract : Chilli (containing the active ingredient capsaicin) forms an important flavouring agent in the preparation of meals in the tropics. Previous studies have shown that capsaicin in high doses causes gross structural and functional changes in the gut.The present study investigates the effect of pure capsaicin on the absorption of glucose, water and alanine by the small intestine of the rat.

Perfusion studies were carried out using a 10 cm jejunal segment. Absorption rates of glucose, water and alanine from a control solution containing the nutrient and from a test solution containing added capsaicin were compared. Recovery of absorptive function of the intestinal mucosa after exposure to capsaicin was also studied.

Absorption of water, glucose and alanine was found to be significantly reduced in the presence of capsaicin. Recovery of absorptive function occurred when capsaicin was withdrawn from the perfusate.

It was concluded that capsaicin adversely affected absorption of nutrients from the rat small intestine; this effect was reversible at least in the case of some nutrients.

Key words: capsaicin small intestine absorption

INTRODUCTION

Capsicum or chilli forms an important spice and flavouring agent in the preparation of meals in the tropics. Capsaicin (8-methyl-N-vanillyl-6-nonenamide), a pungent principle found in the plant genus Capsicum is responsible for the irritation of the skin and mucous membranes observed on contact (1).

Many gastro-intestinal effects have been attributed to capsaicin. An analogue of capsaicin as well as dry capsicum powder have been found to be responsible for gustatory sweating and increased salivation (2,3). Capsaicin has been shown to cause increased mesenteric blood flow (4), gastric mucosal oedema and hyperaemia (5), and a decrease in the gastric acid output (6). Limlomgwongse, Chaitauchawong and Tongyai (7) demonstrated that crude capsaicin preparations irritate the gastric mucosa. An increase in gastric clearance of aminopyrine (7) and [^{14}C] aniline (6) has also been observed in response to capsaicin. These mechanisms appear to be afferent nerve mediated (6).

Long term effects of consumption of chilli include kidney and liver damage in the rabbit (8), ultrastructural changes in the small intestinal cells and reduction in villous height, reduction in growth rate and fat absorption (9) and structural alterations in the small intestinal villous pattern with infiltration by chronic inflammatory cells (10) in the rat. However, these workers used higher concentrations of chilli than is usual in the diet of most Asian populations.

It appears from these studies that capsaicin, either as a crude extract or in the pure form, causes gross structural changes in the gut in high concentrations. Thus it seemed possible that capsaicin, even in low doses, might induce changes in the rate of absorption of nutrients. Experiments were performed in the present study to assess the effect of pure capsaicin on the absorption of glucose, water and alanine by the small intestine of the rat.

METHODS

Adult female albino rats weighing 200-289 g were anaesthetized with phenobarbitone (0.1 mg/100g) intraperitoneally and a tracheostomy performed. The abdomen was opened by a midline incision and an

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approximately 10 cm loop of jejunum, with the proximal end 2 cm distal to the duodeno-jejunal flexure, was identified and isolated between ligatures, care being taken to maintain the blood supply intact. The proximal and distal ends of the loop were cannulated with polyethylene tubing and gently washed to clear intestinal contents. The loop was then perfused at a rate of 0.23 ml/min with the perfusion fluid at a constant temperature of 37°C.

A preliminary experiment was carried out to determine whether deterioration and destruction of the small bowel occurred during prolonged perfusion. The control solution was used for this purpose. After an initial equilibration period, 10 minute collections were made for a period of 140 minutes.

To study the effect of capsaicin, perfusion was commenced with a control solution without capsaicin. An initial 30 minute equilibration period was allowed, followed by four 10 minute collection periods. The same procedure was next repeated using the test solution containing capsaicin.

To assess recovery after perfusion with capsaicin, a segment of the gut was perfused with the test solution containing capsaicin. After a 30 min equilibration period, four 10 min collections of perfusate were made. Perfusion with the control solution was then commenced. 10 min collections were commenced immediately and continued for 60 to 70 minutes.

The loop of intestine was removed at the end of each experiment, fat and mesentery carefully stripped off and the length and wet weight were measured.

Perfusion Solutions

The control solution consisted of 10 mmol glucose, 124 mmol NaCl and 1m Ci (^{14}C) PEG 4000 per L. PEG gave a count of about 5000 CPM. PEG was used as a non-absorbable volume indicator to assess fluid absorption (11).

The test mixture had the same composition as the control solution; in addition, it contained 40 µg capsaicin per ml. Capsaicin was obtained from Sigma Chemicals Ltd.

The perfusion fluid used to estimate alanine absorption contained in addition 178 mg alanine and 2m Ci (^{3}H) alanine per L.

Analytical Methods

Osmolality was checked by the freezing point depression method using an Advanced Osmometer (Advanced Instruments Inc., Newton Highlands, Mass., USA) and was adjusted to 280 mosmoles/kg by adding the appropriate amount of sodium chloride.

(^{14}C) PEG and (^{3}H) alanine were estimated by using an LKB-Wallace liquid scintillation counter (Ultrobeta 1210). A double labelled sample counting technique described by Reunanen and Soini (12) was used.

Glucose was estimated by the Hexokinase/G6P-DH UV method marketed by Boehringer-Mannheim diagnostica as Test combination glucose. Estimations were carried out in duplicate.

Calculation

Rates of fluid absorption and/or secretion were calculated by a standard method (11). The rate of absorption was calculated as the mean of four observations during four collection periods and expressed as microliters or micrograms per minute per gram wet weight of tissue.

A steady state was maintained during the collection periods. This was confirmed by the uniform PEG CPM values during these periods.

RESULTS

Results of six preliminary perfusion experiments to determine whether the jejunal mucosa deteriorated during prolonged perfusion are shown in figures 1 and 2. There was no appreciable deterioration of absorptive function of glucose and water over a continuous 170 minute perfusion period (including 30 minutes allowed for equilibration).

Rates of absorption of water, glucose and alanine were found to be significantly reduced in the presence of capsaicin ($P = 0.01$), as shown in Table I. However, light microscopy of the intestine after perfusion with capsaicin (40 µg/ml) did not show any histological changes. In view of this fact, it was decided to determine whether absorptive properties recovered after perfusion

TABLE I: Effect of capsaicin on the net absorption rates of water, glucose and alanine from the rat jejunal mucosa; results expressed as mean (SD).

Perfusate	*Absorption rates of*		
	Water ($\mu L.g^{-1}.min^{-1}$)	*Glucose* ($\mu mol.g^{-1}.min^{-1}$)	*Alanine* ($\mu mol.g^{-1}.min^{-1}$)
Control solution	29.9 (SD 8.20)	0.66 (SD 0.17)	0.81 (SD 0.40)
Test solution	15.0 (SD 4.20)	0.49 (SD 0.09)	0.67 (SD 0.01)
P	0.01	0.01	0.01

Wilcoxon signed rank sum test used for comparison of data

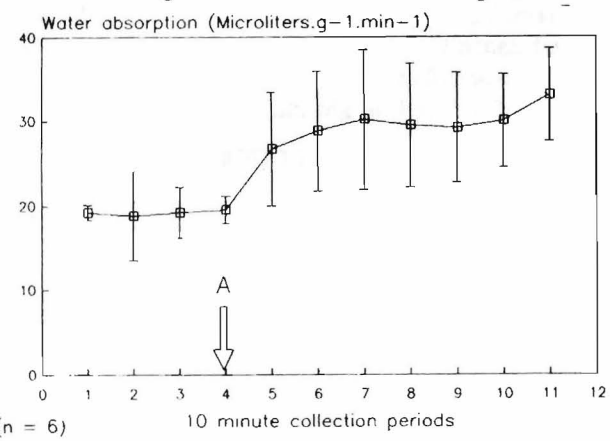

Fig. 1: Absorption of water from the jejunum during prolonged infusion with 10 millimolar glucose-saline solution.

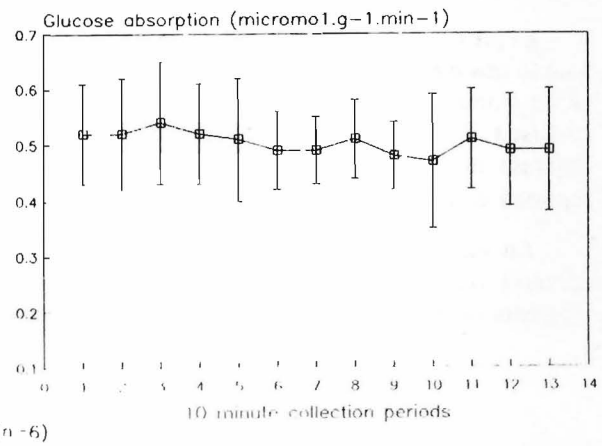

Fig. 2: Absorption of glucose from the jejunum during prolonged infusion with 10 millimolar glucose-saline solution.

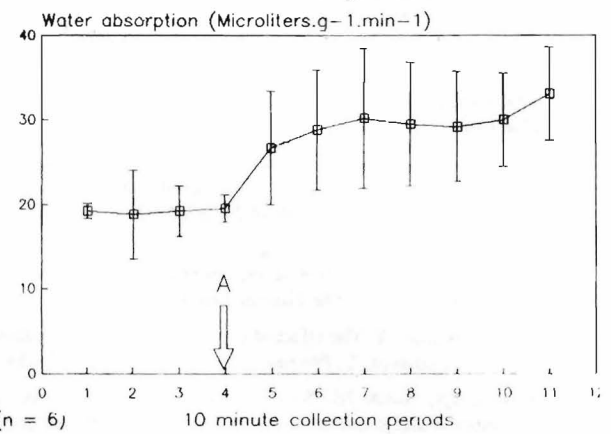

Fig. 3: Recovery of jejunal absorptive capacity for water after infusion with capsaicin (capsaicin was removed from the perfusing solution at point A).

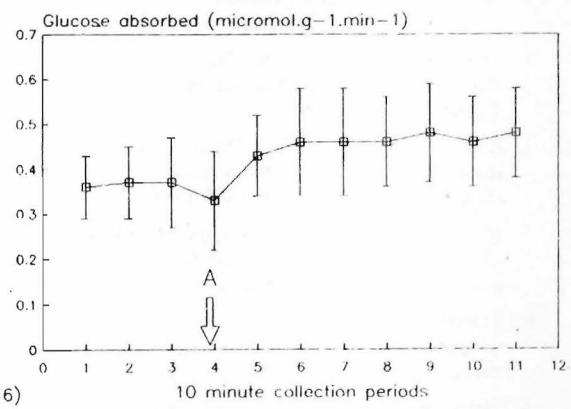

Fig. 4: Recovery of jejunal absorptive capacity for glucose after infusion with capsaicin (capsaicin was removed from the perfusing solution at point A).

with capsaicin. The results of these experiments are shown in figures 3 and 4.

It appears from figure 3 that there is an immediate recovery of water absorption as shown in the upward trend at the arrow (where capsaicin was removed from the perfusate). Recovery of glucose absorption is also seen (figure 4). Recovery of alanine absorption was not studied.

DISCUSSION

The present study demonstrates that capsaicin in acute experiments in the rat causes a reduction of water, glucose and alanine absorption. The effect appears to be temporary at least in the case of water and glucose. Earlier studies (13,14), using an everted-sac technique, have demonstrated a similar reduction in absorptive function in the jejunum of the rat and the hamster. However, much higher concentrations of capsaicin were used in these studies.

In previous studies (5), capsaicin solutions were seen to cause mucosal oedema and increased vascularity of the stomach. No such changes were observed in the perfused jejunal loop on histological examination. Increase in gastro-intestinal motility too have been reported with capsaicin (4).

An increase in the secretion rate could possibly account for the reduced absorption of water and nutrients in the present study. In that case, capsaicin would have to cause a massive increase in intestinal permeability which would probably have been observable as structural changes on histological examination. Therefore it is more likely that capsaicin caused a non-specific generalized depression of absorption.

Capsaicin is known to deplete substance P and somatostatin from sensory nerves and in the dorsal half of the spinal cord in the adult rat (15), but not from intrinsic neurones in the gut (16,17). In view of this, and also due to the fact that the time period of these experiments is too short for any significant depletion of substance P, it is unlikely that capsaicin could have a depressor effect on other gastro-intestinal hormones which, if reduced, might indirectly affect absorption.

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