mimic the phosphoryl group by permitting the formation of a stable, quasi-transition-state complex.

O'Sullivan, W. J., Diefenbach, H. & Cohn, M. (1966). *Biochemistry, Easton*, 5, 2666.

Watts, D. C. & Rabin, B. R. (1962). *Biochem. J.* 85, 507.

Studies on the Effect of Sulphate Nutrition on the Flavour Components of Onion (*Allium cepa*)

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The occurrence of alkyl mono-, di- and tri-sulphides in the volatile components of raw and cooked *Allium* species is well established (e.g. Carson & Wong, 1961; Oaks, Hartmann & Dimick, 1964; Brodnitz, Pollock & Vallon, 1969). The characteristic flavours of certain species, e.g. *A. cepa* (onion), *A. sativum* (garlic) and *A. tuberosum* (Chinese chive), are determined by the proportions of *n*-propyl, allyl and methyl radicals found in the sulphides (Saghir, Mann, Bernhard & Jacobsen, 1964). Varietal differences in onion flavour strength are known (Schwimmer & Guadagni, 1962), but the effects of environmental factors on the volatile flavour components of vegetables have not been reported in any detail. Schwimmer (1968) has described how the flavour components of raw onions manifest themselves by four effects on the sensory organs: a lachrymatory effect, a burning astringency and later a bitter taste on the tongue accompanied by the typical aroma of onion.

We have investigated the relationship between the sulphur nutrition of *A. cepa* (var. White Lisbon) and its flavour components by sensory and g.l.c. methods. The plants were grown in washed sand in a glasshouse and the nutrient solutions contained five concentrations of sulphate (0, 0.05, 0.1, 1 and 3 mequiv/l respectively), the remaining nutrients were at the optimum concentrations (Hewitt, 1966).

The plants were harvested as salad onions after 80 days' growth. Maximum growth was obtained with sulphate concentrations greater than 0.2 mequiv/l. Below this concentration there were symptoms of sulphur deficiency (Wallace, 1961) and the growth response was directly related to sulphate concentration in the nutrient media. Flavour strength as determined by triangular tasting tests, sensory (taste) threshold concentration and pyruvic acid concentration in the expressed juice (Schwimmer & Guadagni, 1962), and peak area in gas-liquid chromatograms of head space vapours, were positively correlated with growth response. Lachrymatory potency increased with the increase in area of the propionaldehyde g.l.c.

peak. As the aldehyde is known to be formed by decomposition of 1-propenylsulphenic acid (Virtanen, 1965), this suggests the basis of an instrumental method of determination of this component.

The conclusions arising from these observations will be discussed.

Brodnitz, M. H., Pollock, C. L. & Vallon, P. P. (1969). *J. agric. Fd Chem.* 17, 760.

Carson, J. F. & Wong, F. F. (1961). *J. agric. Fd Chem.* 9, 140.

Hewitt, E. J. (1966). *Sand and Water Culture Methods Used in the Study of Plant Nutrition*, 2nd ed. Farnham Royal: Commonwealth Agricultural Bureaux.

Oaks, D. M., Hartmann, H. & Dimick, K. P. (1964). *Analyt. Chem.* 36, 1560.

Saghir, A. R., Mann, L. K., Bernhard, R. A. & Jacobsen, J. V. (1964). *Proc. am. Soc. hort. Sci.* 84, 386.

Schwimmer, S. (1968). *Phytochemistry*, 7, 401.

Schwimmer, S. & Guadagni, D. G. (1962). *J. Fd Sci.* 27, 94.

Virtanen, A. I. (1965). *Phytochemistry*, 4, 207.

Wallace, T. (1961). *The Diagnosis of Mineral Deficiencies in Plants*. London: H. M. Stationery Office.

The Interaction of Sulphate Esters and Glutathione *in vivo*

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The finding that the administration of certain carboxylic acid esters of 1-menaphthyl alcohol to rats is followed by the excretion of 1-menaphthylmercapturic acid (Hyde & Young, 1968) led us to investigate the possibility that sulphate esters also give rise to the formation of mercapturic acids *in vivo*. The acid sulphate esters of benzyl alcohol and 1-menaphthyl alcohol were prepared by the action of chlorosulphonic acid on the alcohols in pyridine solution and were separated as their sodium salts. After the injection of sodium benzyl sulphate and sodium 1-menaphthylsulphate into rats, benzylmercapturic acid and 1-menaphthylmercapturic acid were isolated from the urine of the dosed animals in amounts corresponding to the conversion of 8.3 and 5.0% respectively of the administered sulphate esters.

Rat liver contains enzymes that catalyse the conjugation of certain foreign compounds with GSH to form *S*-substituted derivatives (Boyland & Chasseaud, 1969) and it is now generally accepted that this reaction is an early step in the formation of mercapturic acids. This prompted us to determine whether an aralkyl sulphate may participate in an enzyme-catalysed *S*-aralkylation of glutathione. A 100000g supernatant fraction from a rat liver