

Temp.	Benzene		Chlorobenzene		Carbon tetrachloride	
	$\sigma_c$	$\sigma_f$	$\sigma_c$	$\sigma_f$	$\sigma_c$	$\sigma_f$
0°C	5.87 $10^{-8}$ cm.	5.80 × $10^{-8}$ cm.	6.15 × $10^{-8}$ cm.	6.17 × $10^{-8}$ cm.	6.03 × $10^{-8}$ cm.	6.03 × $10^{-8}$ cm.
40	5.97	5.97	6.23	6.24	6.13	6.12
80	6.05	6.05	6.32	6.33	6.25	6.23
120	6.21	6.21	6.42	6.42	6.39	6.37
160	6.38	6.37	6.53	6.54	6.57	6.55
210	6.63	6.62	6.68	6.69	6.85	6.81

Hence, neglecting  $d$  which is usually small and rewriting,

$$[P] \cdot \frac{D}{M} = 2.873 (1 - T_r)^{3.10} \text{ or}$$

$$[P] V = 2.873 (1 - T_r)^{3.10},$$

where  $V$  is the molecular volume.

This relation between molecular volume and parachor is useful in calculating molecular diameters of substances at any temperature. The above expression gives

$$V = \frac{[P]}{2.873 (1 - T_r)^{3.10}}$$

If molecules are assumed to be elastic spheres closely packed together, it is calculated that

$$\sigma = 1.326 \cdot 10^{-8} \sqrt[3]{V} \text{ cm.}, \quad (i)$$

where  $\sigma$  is the molecular diameter. Substituting for  $V$  in (i),

$$\sigma = 1.326 \cdot 10^{-8} \sqrt[3]{\frac{[P]}{2.873 (1 - T_r)^{3.10}}} \text{ cm.}$$

$$= 0.933 \cdot 10^{-8} \frac{[P]^{1/3}}{(1 - T_r)^{1.10}} \text{ cm.} \quad (ii)$$

It may be remarked that if  $\gamma_0$  varies between 60 and 80 (see reference 2), the values of  $\gamma_0$  under extreme cases, may be taken as  $68.2 = 12$ . Since the value of  $\gamma_0$  employed in deducing equation (ii) is the reciprocal of the 12th root, the maximum possible error in calculating the value of  $\sigma$  would be 1.5%.

In the above table, the values of molecular diameters for three substances at six different temperatures are calculated by both the equations (i) and (ii). The values of  $\sigma_c$  are obtained by equation (i), from  $V = M D$  where  $M$  is the molecular weight and  $D$  is the density of the liquid. Density data at various temperatures are taken from Sugden's paper 4;  $\sigma_f$  is calculated by equation (ii).

The good agreement between the two sets of values of molecular diameters of non-associated liquids is a proof regarding the validity of the equation (ii) proposed for calculating molecular diameters in normal liquids, over a wide range of temperatures. Strictly speaking, the values of  $\sigma$  represent the upper limits of the

average distances between the centres of adjacent molecules in the liquid state.

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1. Sugden, *J. Chem. Soc.*, 1927, p. 1783. 2. Sugden *Ibid.*, 1784. 3. Sugden, *Ibid.*, 1781. 4. Sugden, *Ibid.* 1782.

## VITAMINS, MINERALS, CARBOHYDRATES AND PROTEINS IN FRUITS—II

THE amount of minerals such as calcium and phosphorus and of vitamins that take part in human metabolism are not large. Therefore one may look for a supply of these essentials in fruits though in small quantities, but in the soluble form. In the investigation presented here we have analysed ten fruits for protein, sugars, calcium, phosphorus, vitamin B<sub>1</sub> and in some, vitamin C. Water and trichloroacetic acid extracts and ash of the fruits were examined for soluble and insoluble constituents.

Detailed estimations of carbohydrates are published elsewhere.<sup>1</sup> Brigg's colorimetric method for phosphorus, McCrudden's volumetric method for calcium and Kjeldhal's method for protein were adopted. For vitamins C and B<sub>1</sub> the water extract of fruit was taken. For the estimation of vitamin C dichlorophenol-indophenol method<sup>2</sup> was adopted. In the case of vitamin B<sub>1</sub> the quantity of water used for extraction was kept large. The extract was clarified with the minimum quantity of basic lead acetate and sulphuric acid and was then treated with norite. Pure vitamin was retained by norite which was later on released by acidulated water and estimated by using thiochrome method by H. Tauber.<sup>3</sup> Details will be published elsewhere.

All fruits contain sugars and some have starch in addition. Sugars present are mainly glucose and fructose. The concentration of phosphorus from water and acid extracts and from ash is same and is in ortho condition. Same is true with calcium except in sapota.

Analysis of 100 gm. of Fruit

Common Name	Botanical Name	Proteins gm.	Sugars gm.	Phosphorus gm.	Calcium gm.	Vitamin B <sub>1</sub> mgm.	Vitan in C mgm.
1. Chiku .. ..	<i>Sapota zapolilla</i>	0.938	9.21	0.012	0.019	0.078	
2. Orange .. ..	<i>Citrus aurantium</i>	0.628	8.31	0.013	0.013	0.108	53.5
3. Figs .. ..	<i>Ficus carica</i>	1.114	9.07	0.024	0.052	0.042	
4. Guava .. ..	<i>Psidium guajava</i>	1.39	9.44	0.028	0.109	0.045	
5. Plantain—Velchi ..	<i>Musa sapientum</i>	1.15	18.33	0.02	0.003	0.138	0.82
6. Plantain—Green Skin	“ ”	1.07	17.83	0.039	0.003	0.132	
7. Plantain—Rasbali .	“ ”	1.11	18.07	0.027	0.006	0.126	
8. Apple Red ..	<i>Pyrus malus</i>	0.25	10.48	0.022	0.007	0.099	1.08
9. Apple—Yellow green	“ ”	0.242	10.50	0.022	0.007	0.090	1.24
10. Grapes—Yellow ..	<i>Vitis vineifera</i>	0.54	14.69	0.016	0.24	0.036	

which has 30 per cent. water-insoluble (acid-soluble) when analysed with skin on, the rest being water-soluble. The amounts of vitamins present are fairly high especially B<sub>1</sub> in plantain, apple and sapota.

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1. Rege and Devadatta, *J. Univ. Bomb.*, 1941, **10**, 3, B, 74. 2. *Nature*, 1933, **15**, 132. 3. Tauber, H., *Mikrochem. Acta*, 1938, 108.

A CHROMATOGRAPHIC ADSORPTION METHOD FOR THE ESTIMATION OF THE PROVITAMIN A CONTENT OF FOODSTUFFS

RECENT work<sup>1</sup> from this laboratory has shown that the petroleum ether-methyl alcohol phase partition for the separation of carotene from xanthophyll is unsatisfactory because some coloured but biologically inactive degradation products also remain in the epiphasic layer and are, therefore, estimated as carotene. Errors due to the presence of such non-carotene pigments have been found to be rather high in the case of stored foodstuffs like cereals, pulses and condiments. Further, the inactive isomer, lycopene, is likely to be estimated as carotene while no account is taken of the fact that  $\beta$ -carotene is biologically twice as potent as any of the other pro-vitamins A. A correct estimation of the vitamin A activity of any vegetable material can be made only by determining the amounts of the different provitamins present and employing the formula: Vitamin A activity in International Units =

$$\frac{\mu\text{g of } \beta\text{-carotene}}{0.6} + \frac{\mu\text{g of other provitamins}}{1.2}$$

Chromatographic adsorption which offers the only means of separating these pigment

mixtures has not been used as a routine method of estimation since the pigments may be lost to the extent of 10 to 20 per cent. due to incomplete elution from the adsorbent. However, by the application of the chromatographic adsorption in two stages and by a choice of suitable adsorbents, it has been possible to estimate firstly, the total carotene (including lycopene, if present, but no artifacts) and then the relative proportions of the constituent pigments. After repeated trials with a number of substances, dicalcium phosphate prepared according to Moore<sup>2</sup> was found to be satisfactory for the first chromatography. Xanthophylls and artifacts are strongly adsorbed by it, while carotene and lycopene pass down practically unadsorbed. Cryptoxanthin is only weakly adsorbed and, therefore, it can be collected separately by further developing the chromatogram. Recovery experiments with pure  $\beta$ -carotene solutions have shown that the losses are never more than 2 per cent. with a properly prepared adsorbent column.

The carotene solution thus obtained is concentrated to a small volume and chromatographed over a column of Brockmann's alumina. The bands are eluted separately and the different pigments identified and their concentrations determined. The eluates may account for a recovery of about 85 per cent. only but since the three common hydrocarbon pigments— $\beta$ -carotene,  $\alpha$ -carotene and lycopene—differ very slightly in their adsorbabilities, it may be reasonably assumed that the losses would be proportionate. Using this proportion the quantities of the individual pigments present in the original carotene extract (first chromatography) are calculated.

A number of foodstuffs have been assayed for their provitamin A content employing the extraction procedure described in an earlier paper<sup>3</sup> in conjunction with the adsorption technique described above. All the estimations were on petroleum ether (b.p. 60-75° C.) solutions, taking readings at three wavelengths (450, 470 and 480  $m\mu$ ) in a visual spectrophotometer and employing extinction coefficients derived from a sample of pure  $\beta$ -carotene isolated from Badami mango fruit.<sup>4</sup>