LXXIX. THE ESTIMATION OF POTASSIUM AND THE POTASSIUM CONTENT OF NORMAL VOLUNTARY MUSCLE

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POTASSIUM forms an insoluble complex with sodium, silver or lead cobaltinitrite. Kramer & Tisdall [1921] used sodium cobaltinitrite to estimate the K content of sera. Other workers [Robinson & Putnam, 1936; Truszkowski & Zwemer, 1936; Ismail & Harwood, 1937] have used silver cobaltinitrite. Ismail & Harwood, in the estimation of the K content of soils, added silver nitrate solution to the soil solution, and then Kramer & Tisdall's reagent to precipitate the complex potassium salt. The potassium silver cobaltinitrite compound they obtained was thought to consist of mixtures of $K_2AgCo(NO_2)_6$ and $KAg_2Co(NO_2)_6$.

The method described below shows that it is possible to make a single precipitating reagent—a silver sodium cobaltinitrite—and that in the resulting potassium complex there is a different potassium silver relationship from any previously described.

The K content of normal muscles has been determined by this method.

Reagent. 22.6 g. cobalt acetate are ground up with 16.9 g. silver nitrate and placed in a 500 ml. flask; 8 ml. water and 22 ml. glacial acetic acid are added. To this are added 80 ml. water containing 44 g. sodium nitrite. After leaving overnight this solution is filtered and the filtrate aerated for 4 hr. It is stored in the ice chest and filtered prior to use.

Method. Serum (1 ml.) or muscle (containing from 0.1–2.0 mg. K, i.e. up to about 1–2 g. muscle) is reduced to a white ash in a silica crucible in a small electric oven at a temperature of about 350°, with sufficient conc. HNO_3 to remove all halides. When the crucible is cold, the ash is dissolved in 3 ml. water; 2 ml. of this are placed in a centrifuge tube and 2 ml. of the silver sodium cobaltinitrite reagent added. After standing $\frac{1}{2}$ –1 hr. 50 % acetone is added and the tubes are centrifuged. The supernatant fluid is decanted off and the precipitate is washed with more 50 % acetone and then finally with pure acetone. The tubes and precipitate are dried in a water bath and 3 ml. conc. HNO_3 are added. After the precipitate has dissolved, some 15–20 ml. water and a little ferric sulphate are added and the tubes are placed in a boiling water bath for 2 hr. The tubes are left overnight in the ice chest and the amount of silver nitrate present is estimated by titrating with $N/500$ potassium thiocyanate. (A tube containing a known amount of potassium nitrate can be treated in the same manner in order to check the method, although this is really unnecessary as no variation in the ratio K/Ag has ever occurred.)

Calculation: $\frac{\text{ml. } N/500 \text{ thiocyanate used}}{5} \times \text{factor } (0.585) \times \frac{3}{2} = \text{mg. K in sample taken.}$

The method was initially tested with known amounts of potassium nitrate and it was found that the proportion of K to Ag in the compound was as 3 mol.

of the former to 2 mol. of the latter. Therefore, from this relation, a factor could be calculated which would convert ml. of thiocyanate used in the titration into mg. of K. This factor is 0.585 for N/100 thiocyanate. This method has been in use for the past two years and no variation in the relation has been observed.

If the sodium silver cobaltinitrite is dried, a pale brown substance is obtained which contains sodium, silver and the cobaltinitrite radicle. If this solid is re-dissolved in the appropriate quantities of glacial acetic acid and water, it yields the original reagent in liquid form.

Solubility of potassium silver cobaltinitrite. The solubility of the complex is 1 in 61,000 after leaving it in contact with water at room temperature for 1 week.

The almost complete insolubility of this compound is in striking contrast to that of the sodium potassium salt such as is prepared in Kramer and Tisdall's method. Some workers still use water to wash the sodium potassium cobaltinitrite precipitate, although the use of acetone is now the more common procedure. The following few examples show the differences in recovery obtained by the three methods, and it is seen that there is an increasing loss of K as one passes from the first to the last column, showing conclusively these differences in solubility.

Table I

Amount of K recovered, mg.

Amount of K taken, mg.	Author's method	Kramer & Tisdall's method	
		Precipitate acetone-washed	Precipitate water-washed
1.3	1.295	1.284	1.272
0.97	0.968	0.896	0.892
0.8	0.802	0.781	0.711
0.56	0.564	0.549	0.547

Table II

Mg. K in sample of serum taken	Mg. K added (KNO ₃ used)	Total mg. K in serum and KNO ₃	Mg. K recovered	Difference mg.	% error
0.213	1.26	1.473	1.470	-0.003	-0.2
0.213	0.40	0.613	0.584	-0.029	-4.7
0.273	0.41	0.683	0.663	-0.020	-2.9
0.213	0.44	0.653	0.643	-0.010	-1.5
0.273	1.10	1.373	1.366	-0.007	-0.4
0.213	1.18	1.393	1.425	+0.032	+2.3
0.213	0.58	0.793	0.807	+0.014	+1.8

Recovery experiments. Varying amounts of potassium nitrate were added to sera of known K content and these mixtures were ashed and estimated. The recoveries are given in Table II and show that the error was usually of the order of less than 2 %.

Experiments to determine the exact composition of the K compound were made, but while the precipitate always possessed a constant composition, no simple formula could express its nature, and it is most probably a mixture of cobaltinitrites. Methods that have been used previously have yielded variable results as regards the K content of normal sera in man and this is not surprising in view of the solubility of potassium sodium cobaltinitrite. Such difficulties have been overcome by the use of the method here described, and the results obtained with normal sera have been remarkably constant. The advantages of this method are the accuracy that can be obtained in the final titration, and the high molecular weight of the precipitate, enabling time to be saved as a result of the short period needed for centrifuging.

The one disadvantage is the necessity to ash serum, but the method was originally evolved in order to estimate the K content of normal and abnormal muscle, and it is essential to ash this material irrespective of the method employed for the actual estimation.

Potassium content of normal muscle

Twenty-seven samples of normal voluntary muscles were obtained, mostly by biopsy, and the K contents were determined by the above method. The muscles were taken from various parts of the body. The muscle tissue was carefully dissected to remove any fibrous tissue or fat and cut up into small fragments before weighing. Drying was done in an oven maintained at a temperature of 100°, and was usually complete within 24 hr.

The average content of K was 0.28 % of wet weight of muscle, and 0.98 % of dry weight.

There was a certain degree of variation but this was not related to the situation of the muscle nor was it determined by the sex of the patient. This variation was from 0.2 to 0.35 % of wet weight, and from 0.8 to 1.2 % of dry weight.

Recently, little attention has been paid to the K content of voluntary muscle, but Leulier *et al.* [1935] found 0.4 % by wet weight in a small group of normal muscles. These workers did not dry the muscle before estimation, nor was the technique of the method employed of the same degree of accuracy as that of the foregoing method.

SUMMARY

A method for the estimation of K using a silver cobaltinitrite reagent is described, and its advantages are discussed.

The K content of normal voluntary muscles has been estimated.

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