CHAPTER III

EXPERIMENTAL METHODS

3.1 Determination of Sodium and Potassium.

Activation of sodium and potassium with thermal neutron produces radioisotopes 15 hr. Na^{24} and 12.5 hr. K^{42} respectively.

Na^{24} emits 1.368 and 2.754 Mev gamma rays.

K^{42} emits 1.51 Mev gamma rays.

Although their half-lives and some gamma rays energies are nearly equal, the determination of their quantities can be simultaneously made.

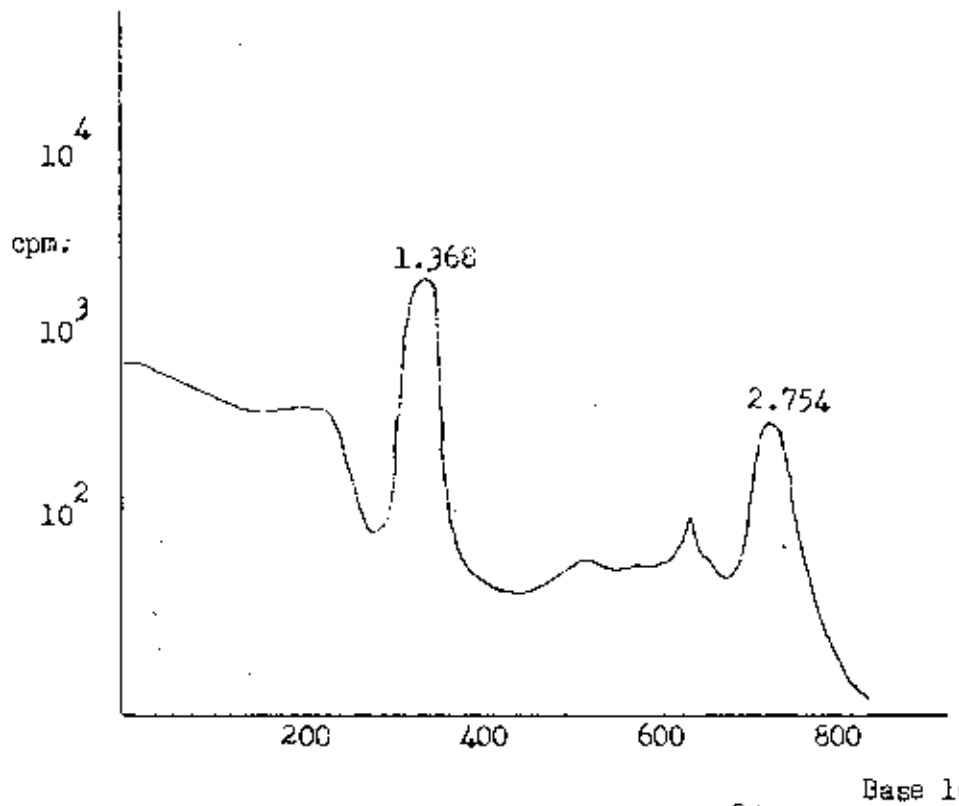

Fig. 3.1 The Gamma-ray Spectrum of Na^{24}

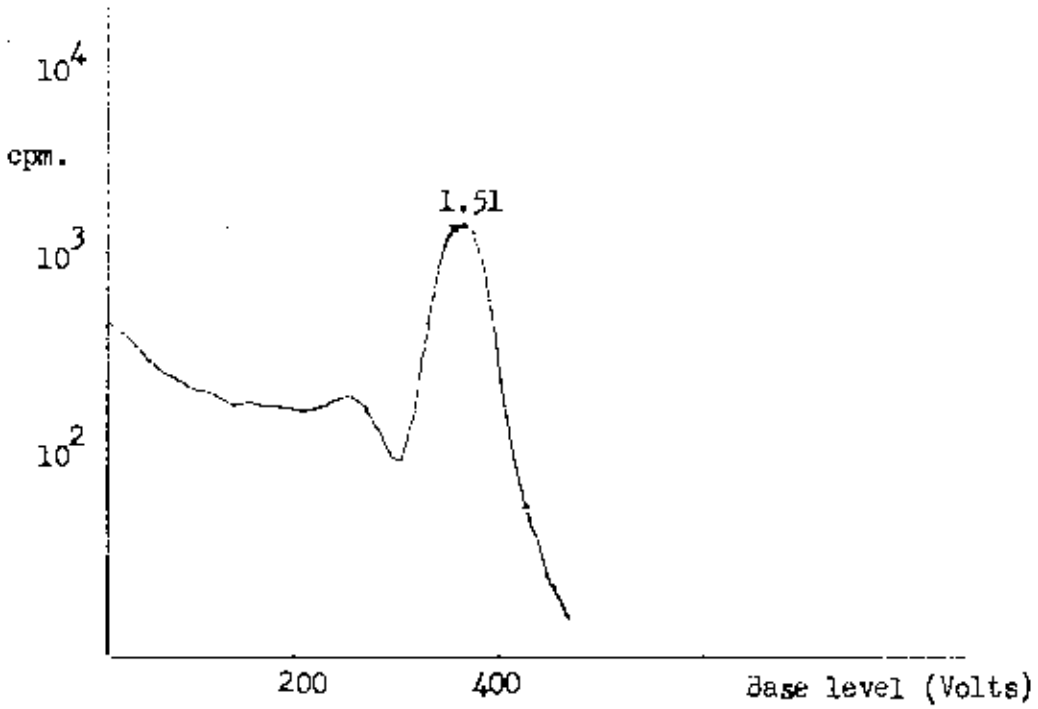

Fig. 3.2 The Gamma-ray Spectrum of K^{42}

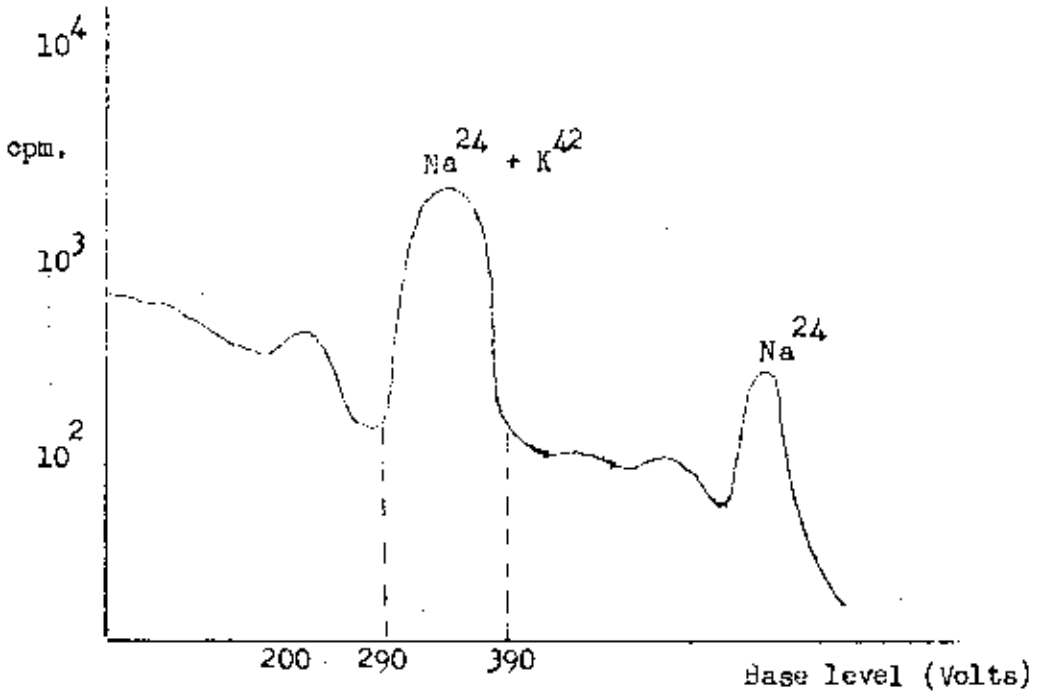

Fig. 3.3 The Gamma-ray Spectrum of $Na^{24} + K^{42}$

Procedure. Sodium carbonate and potassium carbonate were used as the standards. Samples were irradiated for 30 minutes in pneumatic system. The irradiated samples were kept for about 24 hours before counting. The samples were counted by a single channel pulse height analyzer. The counter was set to operate as a differential device at the energy peak of K^{42}. The activity obtained from the count rate was the sum of the activity of Na^{24} and K^{42}. Then the counter was set to operate as a integral device at the base level beyond the high energy peak of Na^{24} (2.75 Mev), so that the activity of potassium does not appear. Standard sodium and standard potassium were irradiated and counted in the same way as the sample so that the weight of sodium and potassium in the sample can be calculated.

The experiment was tried with the known mixtures of sodium and potassium. Using Na_2CO_3 mixed with K_2CO_3 in various ratios and irradiated simultaneously with the standards, and were counted as described above.

For examples.

Na 3.3 mg. and K 24.6 mg. as the standards.

sample No. 1 Na 1.6 mg. + K 14.7 mg.

No. 2 Na 3.6 mg. + K 9.6 mg.

were irradiated for 2 minutes. The count rate were shown in table 3.1

Table 3.1 The Count Rates of Na^{24} and K^{42}

Base level (volts)	Standard sodium (cpm)	Standard potassium (cpm)	Sample No. 1 (cpm)	Sample No. 2 (cpm)
Diff. 360	3913	3735	4200	5974
Int. 800	9849	-	5030	11239

Calculation. No. 1

There are $\frac{3913 \times 5030}{9849} = 2000$ cpm of Na^{24} at energy peak of K^{42}.

Therefore, at energy peak of K^{42} there are 4200 - 2000 cpm of K^{42}.

The weight of potassium was calculated by the equation (2.4)

$$m_x = \frac{24.6 \times 2200}{3735} = 14.5 \text{ mg.}$$

The weight of sodium was directly calculated by comparing with the standard as follows.

$$m_x = \frac{3.3 \times 5030}{9849} = 1.69 \text{ mg.}$$

Similarly, the weight of sodium and potassium of the sample No. 2 can be calculated. The results as shown below.

Na = 3.76 mg.

K = 9.94 mg.

From the above results it may be concluded that this method is applicable in determining the amounts of sodium and potassium in the samples.

Table 3.2 Determination of Sodium in Plants.

Sample	Wt. of sample (mg)	Sodium found (mg)		% of sodium	
		I	II	I	II
Leaf No. 1	50.5	.034	.036	.067	.071
No. 2	48.3	.26	.21	.54	.44
No. 3	75.4	.018	.016	.024	.021
No. 4	55.0	.040	.037	.073	.067
No. 5	45.8	.054	.040	.12	.087
No. 6	37.6	.14	.14	.37	.37
No. 7	68.4	.024	.016	.035	.023
No. 8	132.9	.47	.37	.35	.28
Rice bean	3,585.5	.25	-	.0070	-
Black Gram	3,718.2	.18	-	.0048	-
Soya-bean	3,416.0	.22	-	.0065	-
Green gram	3,967.3	.11	-	.0028	-
Pea nut	3,022.8	.093	-	.0031	-
Paddy	1,381.7	.073	-	.0053	-
Unpolished rice	2,015.6	.040	-	.0020	-
Glutinous rice	2,171.8	.018	-	.00083	-
Car go rice	1,547.4	.063	-	.0041	-
Milled rice	1,695.6	.031	-	.0018	-

Table 3.2 (continued)

Sample	Wt. of sample (mg)	Sodium found (mg)		% of sodium	
		I	II	I	II
Rice flour	1,664.0	.067	-	.0040	-
Wheat flour	1,059.5	.058	-	.0055	-
Cassava	1,472.6	.045	-	.0031	-
Glutinous rice flour	1,574.7	.015	-	.00095	-

Table 3.3 Determination of Potassium in Plants.

Sample	Wt. of sample (mg)	Potassium found (mg)		% of potassium	
		I	II	I	II
Leaf No. 1	50.5	1.4	1.4	2.8	2.8
No. 2	48.3	.99	.81	2	1.7
No. 3	75.4	1.3	1.4	1.7	1.8
No. 4	55.0	1.2	1.3	2.2	2.4
No. 5	45.8	1.8	1.4	3.9	3.0
No. 6	37.6	.86	.74	2.3	2.0
No. 7	68.4	2.1	1.6	3.1	2.3
No. 8	132.9	4.1	3.5	3.1	2.6

Table 3.3 (continued)

Sample	Wt. of sample (mg)	Potassium found (mg)		% of potassium	
		I	II	I	II
Rice bean	3,503.5	46	-	1.3	-
Black gram	3,718.2	48	-	1.3	-
Soya-bean	3,416.0	54	-	1.6	-
Green gram	3,969.3	50	-	1.3	-
Peanut	3,022.8	22	-	.73	-
Paddy	1,381.7	10	-	.72	-
Unpolished rice	2,015.6	10	-	.50	-
Glutinous rice	2,171.8	4.3	-	.20	-
Car go rice	1,547.4	8.3	-	.54	-
Milled rice	1,695.6	4.7	-	.28	-
Rice flour	1,664.0	6.0	-	.36	-
Wheat flour	1,059.5	7.4	-	.70	-
Casseva	1,472.6	3.2	-	.22	-
Glutinous rice flour	1,574.7	5.6	-	.35	-

3.2 Determination of Sodium and Potassium.

(alternative method)

The samples were counted by a single-channel analyzer at the base level 290 volts and window width 100 volts. Standard sodium was counted by setting to operate as a integral device and differential device, and let the count rates were Na_B and Na_W respectively. For standard potassium the count rates were K_B and K_W, and for the sample the count rates were $(Na_{XB} + K_{XB})$ and $(Na_{XW} + K_{XW})$ respectively. (The subscript B refers to the integral, and W refers to the differential).

Let $$\frac{Na_B}{Na_W} = A \quad \ldots\ldots\ldots \quad (3.1)$$

$$\frac{K_B}{K_W} = B \quad \ldots\ldots\ldots \quad (3.2)$$

$$Na_{XB} + K_{XB} = C_1 \quad \ldots\ldots\ldots \quad (3.3)$$

$$Na_{XW} + K_{XW} = C_2 \quad \ldots\ldots\ldots \quad (3.4)$$

Similarly $$\frac{Na_{XB}}{Na_{XW}} = A \quad \ldots\ldots\ldots \quad (3.5)$$

$$\frac{K_{XB}}{K_{XW}} = B \quad \ldots\ldots\ldots \quad (3.6)$$

Substituted the equations (3.5) and (3.6) in the equations (3.3) and (3.4) and solved for Na_{XW} and K_{XW}

$$Na_{XW} = \frac{\alpha C_2 - \beta C_1}{\alpha - \beta} \qquad (3.7)$$

$$K_{XW} = \frac{\alpha C_2 - C_1}{\alpha - \beta} \qquad (3.8)$$

or

$$Na_{XB} = \left(\frac{\alpha}{\beta - \alpha}\right)(\beta C_2 - C_1) \qquad (3.9)$$

$$K_{XB} = \left(\frac{\beta}{\alpha - \beta}\right)(\alpha C_2 - C_1) \qquad (3.10)$$

Then the weights of sodium and potassium in the sample were determined by comparing with the standards. Before applying this method to the samples, the known various ratios of the mixtures of sodium and potassium were tested.

For example.

Na 3.3 mg and K 24.6 mg as the standards.

Sample No. 1 Na 1.8 mg + K 16.2 mg.

No. 2 Na 3.7 mg + K 8.8 mg.

were irradiated for 2 minutes. The count rates were shown in table 3.4.

Table 3.4 The Count Rates of Na^{24} and K^{42}. (alternative method)

	Standard sodium (cpm)	Standard potassium (cpm)	Sample No. 1 (cpm)	Sample No. 2 (cpm)
Int. (B)	214206	27940	132588	260251
Diff. (W)	78140	21832	55819	98523

Calculation No. 1

From eq. (3.1) and (3.2)

$$\alpha = \frac{214206}{78140} = 2.745$$

$$\beta = \frac{27940}{21832} = 1.278$$

and from eq. (3.7) and (3.8)

$$^{Na}_{XW} = \frac{C_1 - \beta C_2}{\alpha - \beta} = \frac{132588 - 1.278 \times 55819}{1.467}$$

$$= 41800 \text{ cpm}$$

Applying eq. (2.4) the weight of sodium was obtained.

$$= \frac{3.3 \times 41800}{78140} = 1.76 \text{ mg}$$

$$K_{XW} = \frac{\alpha C_2 - C_1}{\alpha - \beta} = \frac{2.745 \times 55819 - 132588}{1.467}$$

$$= 14050 \text{ cpm}$$

$$= \frac{24.6 \times 14050}{21832}$$

$$= 15.85 \text{ mg}$$

The weight of sodium and potassium in the sample No. 2 can be calculated in the same way. Na = 3.9 mg, K = 8.28 mg.

The results were shown that eq. (3.7) and (3.8) are applicable for determination of sodium and potassium.

Results of analyses are shown in table 3.5 and 3.6.

Table 3.5 Determination of Sodium in Plants. (alternative method)

Sample	Wt. of sample (mg)	Sodium found (mg)		% of sodium	
		I	II	I	II
Leaf No. 1	50.5	.035	.039	.069	.077
No. 2	48.3	.27	.21	.56	.44
No. 3	75.4	.017	.023	.023	.030
No. 4	55.0	.039	.041	.071	.074
No. 5	45.8	.060	.046	.13	.10
No. 6	37.6	.14	.14	.37	.37
No. 7	68.4	.030	.023	.044	.034
No. 8	132.9	.48	.38	.36	.29
Rice bean	3585.5	.21	-	.0059	-
Black gram	3718.2	.13	-	.0035	-
Soya-bean	3416.0	.23	-	.0067	-
Green gram	3969.3	.12	-	.0030	-
Pea-nut	3022.8	.11	-	.0036	-
Paddy	1381.7	.070	-	.0051	-
Unpolished rice	2015.6	.045	-	.0022	-
Glutinous rice	2171.8	.019	-	.00088	-
Car go rice	1547.4	.066	-	.0043	-
Milled rice	1695.6	.033	-	.0019	-

Table 3.5 (continued)

Sample	Wt. of sample (mg)	Sodium found (mg)		% of sodium	
		I	II	I	II
Rice flour	1664.0	.069	-	.0041	-
Wheat flour	1059.5	.060	-	.0057	-
Cassava	1472.6	.045	-	.0031	-
Glutinous rice flour	1574.7	.017	-	.0021	-

Table 3.6 Determination of Potassium in Plants. (alternative method)

Sample	Wt. of sample (mg)	Potassium found (mg)		% of potassium	
		I	II	I	II
Leaf No. 1	50.5	1.5	1.2	3.0	2.4
No. 2	48.3	1.2	.88	2.5	1.8
No. 3	75.4	1.5	1.2	2.0	1.6
No. 4	55.0	1.4	1.4	2.5	2.5
No. 5	45.8	1.9	1.4	4.1	3.1
No. 6	37.6	1.1	.81	2.9	2.2
No. 7	68.4	2.2	1.7	3.2	2.5
No. 8	132.9	3.9	3.3	2.9	2.5

Table 3.6 (continued)

Sample	Wt. of sample (mg)	Potassium found (mg)		% of potassium	
		I	II	I	II
Rice bean	3585.5	48	-	1.3	-
Black gram	3718.2	49	-	1.3	-
Soya-bean	3416.0	54	-	1.6	-
Green gram	3969.3	45	-	1.1	-
Pea-nut	3022.8	22	-	.73	-
Paddy	1381.7	11	-	.80	-
Unpolished rice	2015.6	10	-	.50	-
Glutinous rice	2171.8	4.5	-	.21	-
Car go rice	1547.4	9	-	.58	-
Milled rice	1695.6	4.8	-	.28	-
Rice flour	1664.0	6.5	-	.39	-
Wheat flour	1059.5	7	-	.66	-
Cassava	1472.6	3.3	-	.22	-
Glutinous rice flour	1574.7	5.8	-	.37	-

3.3 Determination of Manganese and Chlorine.

Manganese and Chlorine are activated by thermal neutrons to give Mn^{56} and Cl^{38}, half-lives 2.58 hr. and 37.5 min. The gamma rays of .845, 1.81 and 2.12 Mev. are emitted by Mn^{56}, and of 1.64 and 2.16 Mev. by Cl^{38}.

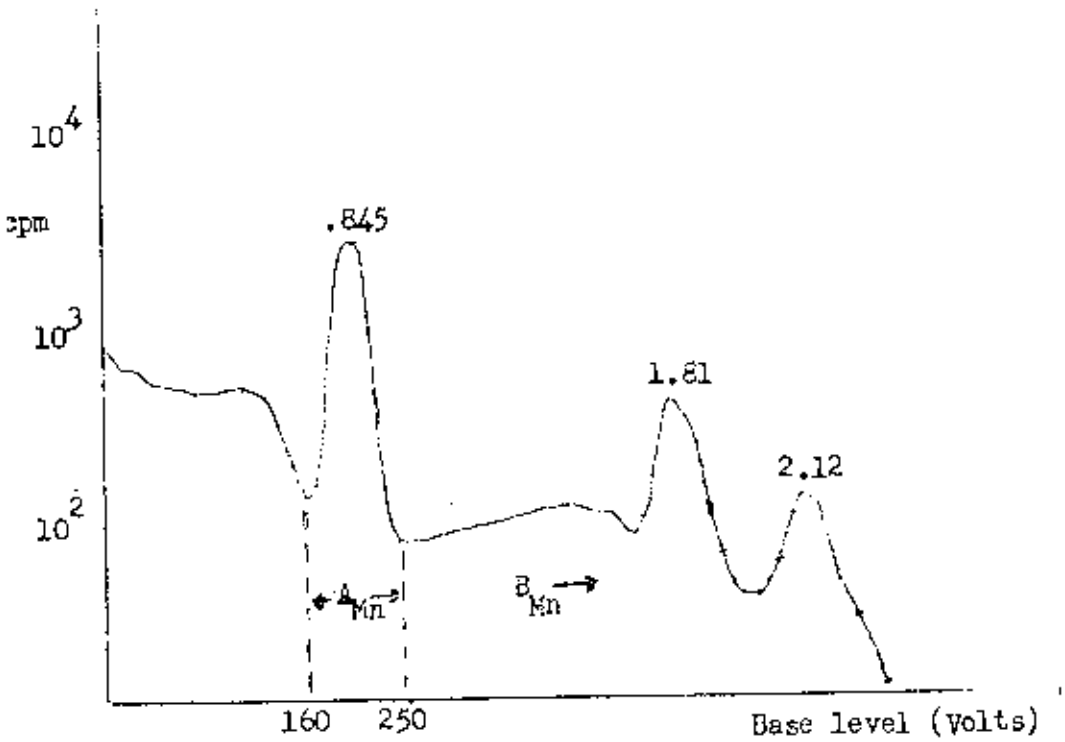

Fig. 3.4 The Gamma-ray Spectrum of Mn^{56}

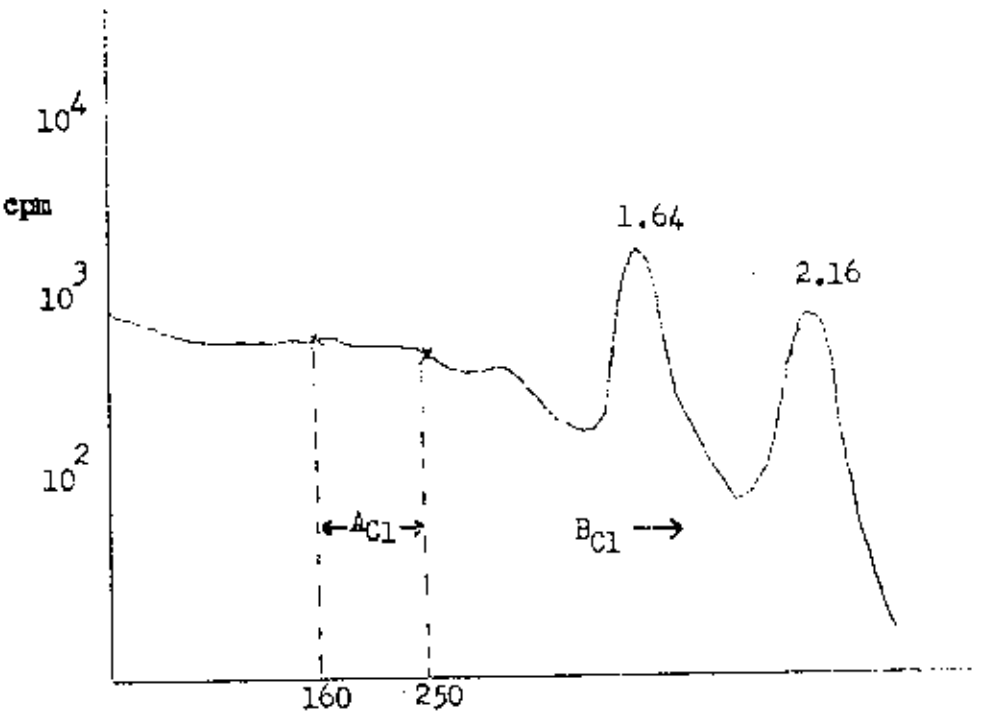

Fig. 3.5 The Gamma-ray Spectrum of Cl^{38}

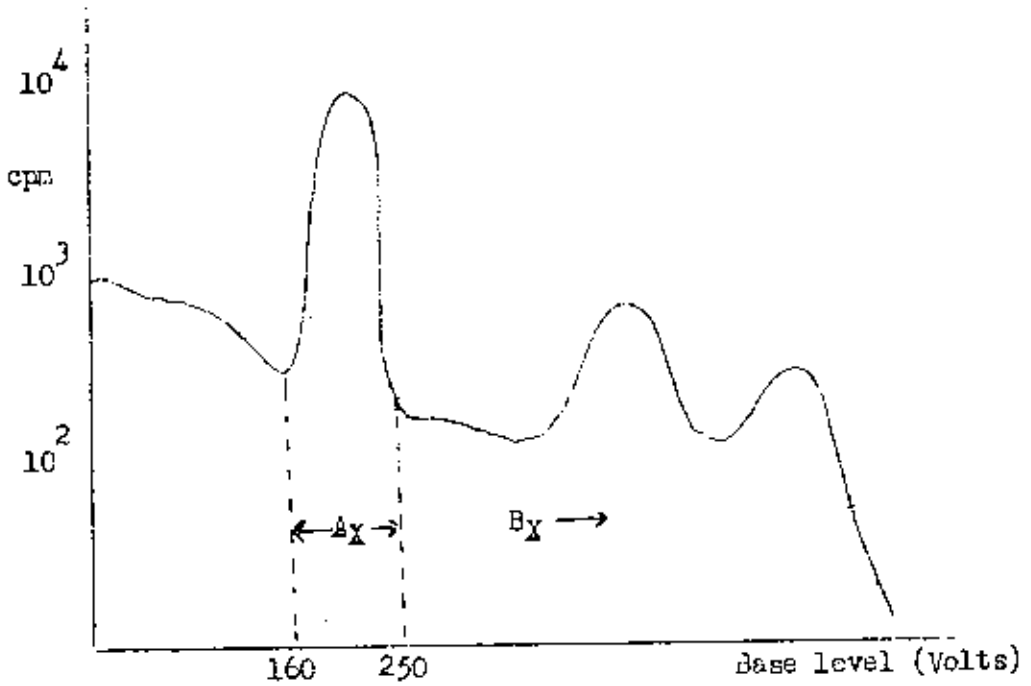

Fig. 3.6 The Gamma-ray Spectrum of Mn^{56} + Cl^{38}

If the activity below .8 Mev. peak of Mn^{56} (between base level 160 and 250 volts) = A_{Mn} , and far beyond this peak (above 250 volts) = B_{Mn} (see Fig. 3.4). The activity of Cl^{38} between base level 160 and 250 volts = A_{Cl} , and above 250 volts = B_{Cl} (see Fig. 3.5).

Let A_X = the activity of Mn^{56} together with Cl^{38} (between base level 160 and 250 volts) and B_X = the activity above 250 volts (see Fig. 3.6)

Let $$\frac{B_{Mn}}{A_{Mn}} = \alpha \qquad \ldots (3.11)$$

$$\frac{B_{Cl}}{A_{Cl}} = \beta \qquad \ldots (3.12)$$

$$A_X = A_{MnX} + A_{ClX} \qquad \ldots (3.13)$$

$$B_X = B_{MnX} + B_{ClX} \qquad \ldots (3.14)$$

Where A_{MnX} , B_{MnX} and A_{ClX} , B_{ClX} are the activities of managanese and chlorine in the sample respectively.

Similarly $$\frac{B_{MnX}}{A_{MnX}} = \chi \qquad \ldots (3.15)$$

$$\frac{B_{ClX}}{A_{ClX}} = \beta \qquad \ldots (3.16)$$

From eq. (3.13), (3.14), (3.15) and (3.16), we get

$$A_{ClX} = \frac{B_X - \alpha A_X}{\beta - \alpha} \quad \ldots\ldots (3.17)$$

$$A_{MnX} = \frac{\beta A_X - B_X}{\beta - \alpha} \quad \ldots\ldots (3.18)$$

or

$$B_{ClX} = \frac{B_X - \alpha A_X}{1 - \alpha/\beta} \quad \ldots\ldots (3.19)$$

$$B_{MnX} = \frac{\beta A_X - B_X}{\beta/\alpha - 1} \quad \ldots\ldots (3.20)$$

The weights of manganese and chlorine are determined by comparing with the standards.

Procedure Using the $MnSO_4$ and NH_4Cl as standard manganese and standard chlorine respectively, the known mixtures of $MnSO_4$ and NH_4Cl were mixed in various ratios. The samples were irradiated simultaneously, and the weights of the mixtures were found as in the above method.

For example.

Mn 1.5 mg and Cl 6.5 mg as standards

Sample No. 1 Mn 1.5 mg + Cl 1.9 mg

No. 2 Mn 1.6 mg + Cl 3.6 mg

were irradiated for 5 seconds and were kept for about 15 minutes.

The single channel pulse height analyzer was set to operate as a integral device at the base 160 volts and 250 volts. Substracted the latter from the first, the result was the activity below .8 Mev peak of Mn^{56} which was A_{Mn} (A_{Cl} or A_X). The value at the base level 250 volts was B_{Mn} (B_{Cl} or B_X).

Table 3.7 The Count Rate of Manganese and Chlorine.

Sample	Time	cpm at base level 160 volts	cpm at base level 250 volts
Standard manganese	9:53 a.m.	214,360	99,348
Standard chlorine	9:56 a.m.	100,641	78,634
Sample No. 1	9:58 a.m.	255,797	127,487
Sample No. 2	10:00 a.m.	292,836	150,385

Correcting for decay time by using eq. (2.3)

Table 3.8 (a) (b) Correcting the Count Rate for Decay Time.

(a)

Sample	cpm at 160 volts	cpm at 250 volts	cpm at 160 - 250 volts
Std. Mn	209,500	97,100	112,400
Std. Cl	96,800	75,600	21,200
Sample No. 1	255,797	127,487	128,310

(b)

Sample	cpm at 160 volts	cpm at 250 volts	cpm at 160 - 250 volts
Std. Mn	207,600	96,200	111,400
Std. Cl	93,300	72,900	20,400
Sample No. 2	292,836	150,385	142,451

Calculation No. 1

From eq (3.17) $$A_{ClX} = \frac{B_X - \alpha A_X}{\beta - \alpha}$$

$$\alpha = \frac{97,100}{112,400} = .864$$

$$\beta = \frac{75,600}{21,200} = 3.565$$

$$A_{ClX} = \frac{1.275 \times 10^5 - .364 \times 1.283 \times 10^5}{2.701}$$

$$= 6.12 \times 10^3$$

weight of chlorine $$= \frac{6.12 \times 10^3 \times 6.5}{21200} = 1.88 \text{ mg}$$

From eq (3.18) $$A_{MnX} = \frac{\beta A_X - B_X}{\beta - \alpha}$$

$$= \frac{3.565 \times 1.283 \times 10^5 - 1.275 \times 10^5}{2.701}$$

$$= 1.22 \times 10^5$$

weight of manganese $$= \frac{1.22 \times 10^5 \times 1.5}{1.124 \times 10^5} = 1.6 \text{ mg}$$

In the same way No. 2 can be solved.

Mn = 1.6 mg ; Cl = 3.47 mg

The results has shown that eq. (3.17) and (3.18) can be used for determining the amounts of manganese and chlorine in the samples.

Table 3.9 Determination of Manganese in Plants.

Sample	Wt. of sample (mg)	Manganese found (mg)		% of manganese	
		I	II	I	II
Leaf No. 1	50.5	.054	.042	.11	.083
No. 2	48.3	.014	.010	.029	.021
No. 3	75.4	.013	.011	.017	.015
No. 4	55.0	.026	.025	.047	.045
No. 5	45.8	.057	.046	.12	.10
No. 6	37.6	.0092	.0063	.024	.017
No. 7	68.4	.050	.037	.073	.054
No. 8	132.9	.098	.070	.074	.053
Rice bean	3585.5	.11	-	.0031	-
Black gram	3718.2	.077	-	.0021	-
Soya-bean	3416.0	.13	-	.0038	-
Green Gram	3969.3	.084	-	.0021	-
Pea-nut	3022.8	.082	-	.0027	-
Paddy	1381.7	.038	-	.0027	-
Unpolished rice	2015.6	.035	-	.0017	-
Glutinous rice	2171.8	.023	-	.0011	-
Car go rice	1547.4	.030	-	.0019	-
Milled rice	1695.6	.018	-	.0011	-

Table 3.9 (continued)

Sample	Wt. of sample (mg)	Manganese found (mg)		% of manganese	
		I	II	I	II
Rice flour	1664.0	.020	-	.0012	-
Wheat flour	1059.5	.0095	-	.00090	-
Cassava	1472.6	.0040	-	.00027	-
Glutinous rice flour	1574.7	.021	-	.0013	-

Table 3.10 Determination of Chlorine in Plants.

Sample	Wt. of sample (mg)	Chlorine found (mg)		% of chlorine	
		I	II	I	II
Leaf No. 1	50.5	.31	.31	.61	.61
No. 2	48.3	.43	.42	.89	.87
No. 3	75.4	.24	.23	.32	.31
No. 4	55.0	.37	.31	.67	.56
No. 5	45.8	.26	.26	.57	.57
No. 6	37.6	.31	.30	.82	.80
No. 7	68.4	.50	.52	.73	.76
No. 8	132.9	.69	.67	.52	.50

Table 3.10 (continued)

Sample	Wt. of sample (mg)	Chlorine found (mg)		% of chlorine	
		I	II	I	II
Rice bean	3585.5	1.6	-	.045	-
Black gram	3718.2	1.2	-	.032	-
Soya-bean	3416.0	1.5	-	.044	-
Green gram	3967.3	1.8	-	.045	-
Pea-nut	3022.8	.65	-	.021	-
Paddy	1381.7	1.1	-	.080	-
Unpolished rice	2015.6	.38	-	.019	-
Glutinous rice	2171.8	.34	-	.016	-
Car go rice	1547.4	.31	-	.020	-
Milled rice	1695.6	.28	-	.016	-
Rice flour	1664.0	.33	-	.020	-
Wheat flour	1059.5	.60	-	.057	-
Cassava	1472.6	.19	-	.013	-
Glutinous rice flour	1574.7	.39	-	.025	-

3.4 Determination of Aluminium.

Activation of aluminium with thermal neutron produces only one radioisotope 2.3 min. Al^{28}.

Al^{28} emits gamma-rays of 1.78 Mev.

Using Al_2O_3 as standard aluminium.

Procedure. (6)

I. Standard aluminium and samples were separately irradiated in pneumatic system. The sample was counted at once by a single pluse height analyzer which was set to operate as a differential device at energy peak of Al^{28}. The sample was counted for plotting the decay curve on the semilogarithmic paper. (see Fig. 3.7).

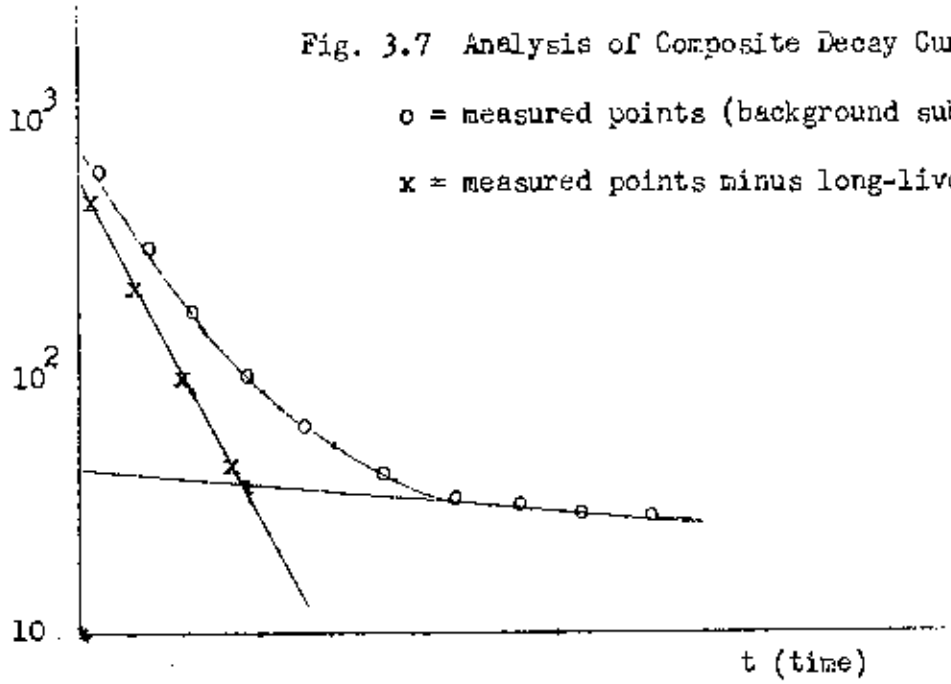

Fig. 3.7 Analysis of Composite Decay Curve.

o = measured points (background substracted)

x = measured points minus long-lived activities

From Fig. 3.7 it appears that the curve can be broken into two straight portions. The straight plot is due to the fact that the activity of Al^{28} has decayed.

Fit a straight line through the experimental points at the right hand end, and substracted the long-lived intensity, as given by this line, from the measured points. Plot the difference representing the activity of Al^{28}. Drawed the best straight line through these points and determined the count rate at $t = 0$. The result was the count rate of Al^{28} from Al^{27}, P^{31} and Si^{28} [Al^{27} (n, γ) Al^{28}, P^{31} (n, α) Al^{28}, Si^{28} (n, p) Al^{28}]

II. Repeat the procedure as in I with cadmium-covered samples so that the reactions are only due to fast neutrons. Determined the count rate of Al^{28} (from P^{31} and Si^{28}) by plotting graph as in I. We can get the count rate of Al^{28} (from Al^{27}) by substracting the count rate in II from I. The weight of aluminium was determined by comparing with the standard.

For example.

Table 3.11 The Count Rates of Aluminium in Plants.

Sample	Wt. of sample (mg)	cpm (Bare)	cpm (Cd-covered)	cpm (Bare - Cd - covered)
Standard Al	.5	186,200	-	186,200
Leaf No. 1	50.5	8,300	2,500	5,800

$$\text{weight of aluminium} = \frac{.5 \times 5800}{186,200} = .016 \text{ mg}$$

$$= \frac{.016 \times 100}{50.5} = .032\%$$

N.B. The count rate of cadmium-covered standard aluminium is very low, it can be neglected.

Table 3.12 Determination of Aluminium in Plants.

Sample	Wt. of sample (mg)	Aluminium found (mg)		% of aluminium	
		I	II	I	II
Leaf No. 1	50.5	.016	.018	.032	.036
No. 2	48.3	.023	.022	.048	.046
No. 3	75.4	.027	.027	.036	.036
No. 4	55.0	.024	.022	.044	.040
No. 5	45.8	.036	.039	.079	.085
No. 6	37.6	.027	.028	.072	.074
No. 7	68.4	.041	.035	.060	.051
No. 8	132.9	.15	.14	.11	.10
Rice bean	3585.5	.057	-	.0016	-
Black gram	3718.2	.099	-	.0027	-
Soya-bean	3416.0	.10	-	.0029	-
Green gram	3967.3	.028	-	.00071	-
Pea-nut	3022.8	.049	-	.0016	-
Rice bean ash	46.9	.068	-	.14	-
Black gram ash	67.2	.16	-	.24	-
Soya-bean ash	28.7	.053	-	.18	-
Green gram ash	74.4	.31	-	.42	-
Pea-nut ash	51.4	.25	-	.49	-
Yellow gram ash	39.6	.13	-	.33	-

Cadmium-covered standard phosphorus was irradiated and counted. The weight of phosphorus in cadmium-covered samples were determined by comparing with standard. The results were shown in table 3.13. The weight obtained is not the actual weight because of the interference of Si^{28}. Actual amounts of phosphorus was later determined by another method to be less than those shown in table 3.13. This indicated that there existed some silicon in the samples.

Table 3.13 Apparent Amounts of Phosphorus in Beans.

Sample	Wt. of sample (mg)	Phosphorus (mg)	Apparent %
Rice bean	3585.5	19	.53
Black gram	3718.2	13	.35
Soya-bean	3416.0	25	.73
Green gram	3967.3	12	.30
Pea-nut	3022.8	13	.43

3.5 Determination of Aluminium. (alternative method)

The single channel pulse height analyzer was set to operate as a integral device at energy peak of Al^{28}. The sample was counted for 30 seconds, and waited for 30 seconds, and then counted for 30 seconds.

Suppose that C_{S1} and C_{S2} are the count rates of standard aluminium, and C_1 and C_2 are the count rates (count rates from cadmium-covered substracted) of the sample.

The weight of aluminium was determined by

$$W_X = \frac{C_1 - C_2}{C_{S1} - C_{S2}} W_S$$

where W_X = weight of aluminium in sample.

W_S = weight of standard aluminium.

For example.

Table 3.14 The Count Rate of Aluminium. (alternative method)

Sample	Wt. of sample (mg)	Counts / 30 sec (Bare)		Count / 30 sec (Cd-covered)		Bare - Cd-covered	
		C_1	C_2	C_1	C_2	C_1	C_2
Std. Al	.5	161,200	117,800	-	-	161,200	117,800
Leaf No.1	50.5	38,750	36,530	11,680	10,980	27,070	25,550

$$\text{weight of aluminium} = \frac{27070 - 25550}{161200 - 117800} \times .5$$

$$= .017 \text{ mg}$$

$$= .034\%$$

Table 3.15 Determination of Aluminium in Plants. (alternative method)

Sample	Wt. of sample (mg)	Aluminium found (mg)		% of aluminium	
		I	II	I	II
Leaf No. 1	50.5	.017	.019	.034	.038
No. 2	48.3	.027	.025	.056	.052
No. 3	75.4	.028	.027	.037	.036
No. 4	55.0	.024	.029	.044	.053
No. 5	45.8	.037	.047	.081	.10
No. 6	37.6	.028	.030	.074	.080
No. 7	68.4	.035	.028	.051	.041
No. 8	132.9	.14	.19	.10	.14

Table 3.15 (continued)

Sample	Wt. of sample (mg)	Aluminium found (mg)		% of aluminium	
		I	II	I	II
Rice bean	3585.5	.061	-	.0017	-
Black gram	3718.2	.089	-	.0024	-
Soya-bean	3416.0	.095	-	.0028	-
Green gram	3967.3	.032	-	.00081	-
Pea-nut	3022.8	.052	-	.0017	-
Paddy	1381.7	.18	-	.013	-
Unpolished rice	2015.6	.20	-	.099	-
Glutinous rice	2171.8	.14	-	.064	-
Car go rice	1547.4	.29	-	.019	-
Milled rice	1695.6	.24	-	.014	-
Rice flour	1567.8	.17	-	.011	-
Wheat flour	1196.4	.088	-	.0074	-
Cassava	1140.9	.11	-	.0096	-
Glutinous rice flour	1271.9	.10	-	.0079	-

3.6 Determination of Phosphorus.

Activation of phosphorus by thermal neutron produces 14.3 days P^{32}.

P^{32} emits no gamma-ray but beta with energy 1.71 Mev.

Procedure. Samples used for determination of phosphorus were beans. Both samples and standard phosphorus (Using $NH_4H_2PO_4$) were irradiated in the beam hole about two months (The schedule of operation was of approximately 2 hours per day (5 days a week) at 1 M.W. including extra operation at low power from time to time). After allowing one week for short half-lived radioisotope to decay, the half-life of the samples were checked, and then phosphorus was found. The weights of phosphorus were determined by comparing with the standard as shown in table 3.16.

3.16 Determination of Phosphorus in Plants.

Sample	Wt. of sample (mg)	Phosphorus found (mg)	% of phosphorus
Rice bean	246.5	.45	.18
Black gram	274.0	.65	.24
Soya-bean	184.7	.68	.37
Green gram	187.9	.42	.22
Pea-nut	215.5	.57	.26

3.7 Determination of Zinc.

Activation of zinc by thermal neutrons produces 245 days Zn^{65} with gamma-ray energy 1.114 Mev.

Procedure. The irradiated samples in 3.6 were kept for about one month and were counted by a multichannel pulse height analyzer. Then sum the count rates under energy peak of Zn^{65} (back ground substracted). The weights of zinc in samples were determined by comparing with the standard. Results of analyses of zinc are shown in table 3.17.

Table 3.17 Determination of Zinc in Plants.

Sample	Wt. of sample (mg)	Zinc found (mg)	% of zinc
Leaf No. 1	47.1	.0042	.0089
No. 2	47.5	.0033	.0069
No. 3	74.3	.0055	.0074
No. 4	54.8	.0062	.011
No. 5	44.5	.0040	.0090
No. 6	36.7	.0051	.014
No. 7	54.5	.0050	.0092
No. 8	130.1	.015	.011
Rice bean	678.2	.027	.0040
Black gram	407.4	.028	.0069
Soya-bean	494.6	.038	.0077
Green gram	663.9	.021	.0032
Pea-nut	660.8	.039	.0059