STUDIES OF THE ASH OF VEGETABLE FOODS

II COMPARISON OF SUMMER SPINACH WITH WINTER SPINACH IN RESPECT TO ASH CONTENT AND ALKALINITY

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In the previous paper[1] the correlation between the ash content and the alkalinity of the spinach harvested in summer was discussed. It was found that there was a considerable fluctuation in the value of each character, depending on the defference in maturity of the materials, and what part of the leaf or stalk was examined, though all the materials were harvested in the same season.

As controlling the ash content and the alkalinity in the plant organism, the environmental conditions seem to be as important as the physiological factors. This paper deals with the ash-content, the alkalinity, and the correlation coefficient between these character in the case of the spinach harvested in winter. The results previously publshed concerning the summer spinach will be cited for comparison.

Materials and Methods

The experiments were carried out from Dec. 1963 to Jan. 1964, using the spinach on the market. The treatment and division of fresh spinach were done in the same way as described in the previous paper[1].

The estimation of dry weight (D.W. %), ash content (A.W. %), alkalinity of water-soluble ash (s-A), alkalinity of water-insoluble ash (i-A), and total alkalinity (t-A) was patterned by the methods reported previously[1].

Results

The spinach was separated into the leaf and stalk; the leaf was further divided into the vein and circumferential part, and the stalk was in turn divided into the top, middle and base part all in the same length.

D.W. %, A.W. %, s-A, i-A, and t-A were respectively estimated on those divided parts of spinach.

In Tab. 1–5, the experimental results are summarized and their mean value and standard deviation are also pnesented. As for each of the character mentioned in those tables, its distribution curve is illustrated in Fig. 1–16.

The character curves obtained from 45 samples of stalk and 30 samples of leaf are illustrated, for comparison with the results of the former experiment with summer spinach where no division of leaf or stalk was performed.

In each figure, the winter type is repre sented with a solid line and the summer type with a dotted line.

Abbreviations used: D.W.%, dry weight; A.W.%, ash content; s-A, alkalinity of water-soluble ash; i-A, alkalinity of water-insoluble ash; t-A, total alkalinity.

Table 1 Dry weight, ash content and alkalinity of circumferential part of leaf.

		D.W. %	A.W. %	A.W. /D.W. %	s—A /F.W. 10g	s—A /D.W. g	s—A /A.W. g	i—A /F.W. 10g	i—A /D.W. g	i—A /A.W. g	t—A /F.W. 10g	t—A /D.W. g	t—A /A.W. g
Value measured	1	12.3	2.05	16.6	11.8	9.6	57.9	17.0	14.4	87.0	28.8	24.0	144.9
	2	13.2	2.47	18.6	13.6	10.3	55.2	21.0	15.8	85.0	34.6	26.1	140.2
	3	13.7	1.76	12.9	7.8	5.7	44.5	11.3	8.3	64.3	19.1	14.0	108.8
	4	13.3	2.20	16.5	11.1	8.3	50.3	15.8	11.9	72.0	26.9	20.2	122.3
	5	14.6	1.92	13.0	7.2	4.8	37.2	17.0	11.6	89.0	24.2	16.4	126.2
	6	14.9	1.74	11.7	9.1	6.1	51.8	12.6	8.5	72.5	21.7	14.6	124.3
	7	14.7	2.07	14.1	11.7	7.9	56.2	14.8	10.1	70.9	26.5	18.0	127.1
	8	16.0	2.07	12.9	11.1	6.9	53.6	16.2	10.1	78.0	27.3	17.0	131.6
	9	14.2	1.85	13.0	6.4	4.5	34.5	15.2	10.6	82.0	21.6	15.1	116.5
	10	16.2	1.93	15.6	9.7	7.8	50.1	12.4	10.0	64.0	22.1	17.8	114.1
	11	15.2	2.00	13.1	12.7	8.3	63.4	13.9	9.1	69.6	26.6	17.4	133.0
	12	15.7	1.96	12.4	8.2	5.0	40.4	23.3	14.8	119.0	31.5	19.8	159.4
	13	17.8	2.17	12.2	10.0	5.6	46.2	19.5	11.0	90.0	29.5	16.6	136.2
	14	17.0	2.82	16.4	21.5	12.6	76.6	21.1	12.2	74.8	42.6	24.8	151.4
	15	16.2	1.80	11.1	12.3	7.6	68.1	17.4	10.7	96.5	29.7	18.3	164.6
Mean	(M)	15.0	2.05	14.00	10.95	7.4	52.4	16.6	11.3	81.0	27.5	18.7	133.3
Standard deviation	(σ)	1.47	0.275	2.12	3.48	2.18	11.0	3.36	2.17	13.9	5.70	3.58	15.78
$\frac{\sigma}{M}\times 100$		9.80	13.40	15.10	31.70	29.50	21.0	20.20	19.20	17.20	20.70	19.20	11.80

Table 2 Dry weight, ash content and alkalinity of vein part of leaf.

		D.W. %	A.W. %	A.W./ D.W. %	s—A /F.W. 10g	s—A /D.W. g	s—A /A.W. g	i—A /F.W. 10g	i—A /D.W. g	i—A /A.W. g	t—A /F.W. 10g	t—A /D.W. g	t—A /A.W. g
Valve measured	1	13.2	1.94	14.8	9.8	7.4	50.1	14.4	10.3	69.8	24.2	17.7	119.9
	2	12.3	2.02	16.4	9.3	7.5	46.0	10.9	8.8	54.0	20.2	16.3	100.0
	3	13.0	1.53	11.7	8.5	6.6	55.2	8.6	6.6	56.5	17.1	13.2	111.7
	4	12.3	1.98	16.0	10.2	8.1	51.9	13.3	10.7	67.0	23.5	18.8	118.9
	5	13.4	1.75	13.0	7.7	5.7	43.9	13.7	10.2	78.3	21.4	15.9	122.2
	6	13.4	1.60	12.0	9.7	7.2	60.2	8.6	6.4	53.1	18.3	13.6	113.3
	7	13.8	2.05	14.8	13.9	10.0	67.8	11.9	8.6	58.0	25.8	18.6	125.8
	8	14.4	1.80	12.5	10.3	7.1	57.1	11.6	8.0	64.2	21.9	15.1	121.3
	9	12.7	1.64	12.9	7.4	5.8	45.0	12.5	9.8	76.1	19.9	15.6	121.1
	10	16.1	1.96	12.2	12.6	7.8	63.8	11.0	6.8	56.0	23.6	14.6	119.8
	11	13.7	2.07	15.1	15.7	11.4	76.0	11.4	8.2	53.8	27.1	19.6	129.8
	12	14.4	1.96	13.6	9.8	6.8	50.2	19.6	13.6	100.0	29.4	20.4	150.2
	13	16.9	2.05	12.2	12.5	7.5	61.2	16.3	9.7	79.5	28.8	17.2	140.7
	14	16.0	2.61	16.2	12.0	13.6	84.3	18.9	11.8	72.8	40.9	25.4	157.1
	15	15.1	1.64	10.8	12.6	8.3	77.0	15.2	10.0	92.5	27.8	18.3	169.5
Mean	(M)	14.05	1.91	13.6	11.5	8.1	59.3	13.2	9.3	68.8	24.7	17.4	128.1
Standard deviation		1.40	0.258	1.74	4.43	2.04	12.05	3.16	1.92	14.02	5.60	3.78	17.95
$\frac{\sigma}{M}\times 100$		9.92	13.5	12.8	39.0	25.2	20.3	24.0	20.6	20.4	22.7	21.7	14.0

Table 3 Dry weight, ash content and alkalinity of top part of stalk.

		D.W. %	A.W. %	A.W. /D.W. %	s—A /F.W. 10g	s—A /D.W. g	s—A /A.W. g	i—A /F.W. 10g	i—A /D.W. g	i—A /A.W. g	t—A /F.W. 10g	t—A /D.W. g	t—A /A.W. g
Value Measured	1	10.8	1.02	9.5	4.5	4.1	43.7	3.5	3.2	33.8	8.0	7.3	77.5
	2	9.61	1.20	12.4	6.3	6.5	52.3	4.1	4.2	33.9	10.4	10.7	86.2
	3	9.50	0.87	9.1	4.6	4.8	53.1	4.7	5.0	54.9	9.3	9.8	108.0
	4	9.96	1.15	11.6	6.1	6.2	53.1	4.7	4.7	40.9	10.8	10.9	94.0
	5	11.2	0.84	7.5	3.8	3.4	44.8	4.3	3.8	50.5	8.1	7.2	95.3
	6	9.7	1.07	11.1	8.2	8.5	76.1	4.7	4.9	43.6	12.9	13.4	119.7
	7	12.0	1.17	9.7	6.0	4.9	51.0	6.0	5.0	51.0	12.0	9.9	102.0
	8	10.2	1.11	10.8	7.4	7.7	67.1	5.6	5.4	50.3	13.0	13.1	117.4
	9	10.9	0.96	8.8	4.9	4.5	51.2	6.5	5.9	67.4	11.4	10.4	118.6
	10	14.1	1.17	8.3	9.6	6.8	81.5	7.8	5.5	66.2	17.4	12.3	147.7
	11	11.2	1.30	11.8	11.5	10.4	88.5	7.8	7.1	60.4	19.3	17.5	148.9
	12	11.6	1.14	9.9	4.0	4.4	44.6	9.7	8.4	85.2	13.7	12.8	129.8
	13	13.9	0.96	6.9	4.6	3.3	48.1	7.1	5.1	73.9	11.7	8.4	122.0
	14	12.6	1.39	11.0	10.1	8.0	72.6	8.9	7.0	63.9	19.0	15.0	136.5
	15	12.3	0.83	6.7	5.5	4.5	67.0	7.2	5.8	86.9	12.7	10.3	153.9
Mean	(M)	11.3	1.08	9.7	6.5	5.9	59.7	6.2	5.4	57.5	12.7	11.3	117.2
Standard deviation		1.41	0.159	1.64	2.31	2.02	14.10	1.81	1.29	13.20	3.40	2.72	22.8
$\frac{\sigma}{M} \times 100$		12.40	14.7	16.9	35.50	34.10	23.60	29.10	23.90	35.20	26.80	24.0	19.40

Table 4 Dry weight, ash content and alkalinity of middle part of stalk.

		D.W. %	A.W. %	A.W. /D.W. %	s—A /F.W. 10g	s—A /D.W. g	s—A /A.W. g	i—A /F.W. 10g	i—A /D.W. g	i—A /A.W. g	t—A /F.W. 10g	t—A /D.W. g	t—A /A.W. g
Value measured	1	9.9	0.95	9.5	3.3	3.3	35.0	2.2	2.2	23.7	5.5	5.5	58.7
	2	8.52	1.08	12.6	6.3	7.3	58.0	2.9	3.4	26.7	9.2	10.7	84.7
	3	7.9	0.81	10.1	4.3	5.3	53.0	4.2	5.2	51.2	8.5	10.5	104.2
	4	8.26	1.08	13.1	6.6	8.0	61.0	4.3	5.2	39.8	10.9	13.2	100.8
	5	10.6	0.86	8.1	4.5	4.2	51.7	4.4	4.1	50.9	8.9	8.3	102.6
	6	8.6	0.88	10.1	6.8	7.8	77.7	3.3	3.9	38.0	10.1	11.7	115.7
	7	10.7	1.06	9.4	6.2	5.8	61.1	4.8	4.5	47.5	11.0	10.3	108.6
	8	9.0	0.92	10.2	4.7	5.3	51.4	4.5	5.0	48.7	9.2	10.3	100.1
	9	9.9	0.89	9.0	4.8	4.9	54.0	4.8	4.9	54.0	9.6	9.8	108.0
	10	12.7	1.05	8.3	8.2	6.5	77.9	6.9	5.4	64.9	15.1	11.9	142.8
	11	10.3	1.13	11.0	10.3	10.0	90.5	5.8	5.6	51.2	16.1	15.6	141.7
	12	10.5	0.97	9.2	3.9	3.8	40.6	7.9	6.4	81.5	11.8	10.2	122.1
	13	12.0	0.86	7.1	4.4	3.7	51.7	6.0	5.0	70.0	10.4	8.7	121.7
	14	11.0	1.13	10.3	8.0	7.3	70.6	5.9	5.4	52.7	13.9	12.7	123.3
	15	10.5	0.73	6.9	5.0	4.7	68.2	5.5	5.2	75.8	10.5	9.9	144.0
Mean	(M)	10.03	0.96	9.7	5.8	5.9	60.2	4.9	4.8	51.8	10.7	10.6	111.9
Standard deviation		1.33	0.119	1.68	1.85	1.85	14.20	1.45	0.985	12.23	2.60	2.24	22.0
$\frac{\sigma}{M} \times 100$		12.90	12.40	17.40	31.80	31.40	23.5	29.60	20.50	23.70	24.30	21.10	19.70

Table 5 Dry weight, ash content and alkalinity of base Part of stalk.

		D.W. %	A.W. %	A.W. /D.W. %	s—A /F.W. 10g	s—A /D.W. g	s—A /A.W. g	i—A /F.W. 10g	i—A /D.W. g	i—A /A.W. g	t—A /F.W. 10g	t—A /D.W. g	t—A /A.W. g
Value measured	1	10.2	0.95	9.3	2.9	2.9	30.6	2.5	2.4	26.1	5.4	5.3	56.7
	2	8.50	1.20	14.1	5.7	6.8	48.2	3.2	3.7	26.1	8.9	10.5	74.3
	3	7.8	0.87	11.2	4.2	5.4	47.6	4.3	5.5	48.9	8.5	10.9	96.5
	4	7.88	1.14	14.4	6.1	7.8	54.0	3.8	4.8	33.2	9.9	12.6	87.2
	5	10.6	0.79	7.4	2.6	2.5	33.1	4.4	4.1	55.2	7.0	6.6	88.3
	6	8.0	0.91	11.4	5.7	7.2	62.9	2.6	3.3	28.8	8.3	10.5	91.7
	7	10.9	1.04	9.6	5.4	5.0	51.8	4.9	4.5	46.9	10.3	9.5	98.7
	8	9.0	0.99	11.0	4.8	5.4	48.6	4.5	5.0	45.2	9.3	10.4	93.8
	9	10.1	0.93	9.2	3.7	3.6	39.5	5.0	4.9	53.5	8.7	8.5	93.0
	10	13.4	1.02	7.6	6.8	5.0	65.9	6.2	4.6	60.6	13.0	9.6	126.5
	11	10.4	1.12	10.8	7.0	6.7	62.3	6.0	5.8	54.0	13.0	12.5	116.3
	12	10.6	1.00	9.4	3.2	3.0	31.6	6.1	5.7	60.8	9.3	8.7	92.4
	13	12.3	0.93	7.6	4.0	3.3	42.8	6.1	5.0	65.2	10.1	8.3	108.0
	14	11.7	1.17	10.0	6.3	5.3	53.2	6.8	5.8	57.9	13.1	11.1	111.1
	15	10.8	0.83	7.7	5.8	5.4	69.9	6.4	6.0	77.7	12.2	11.4	147.6
Mean	(M)	10.15	0.99	10.1	5.0	5.0	49.5	4.9	4.8	49.3	9.8	9.8	98.8
Standard deviation		1.59	0.120	1.99	1.38	1.61	12.0	1.36	0.99	14.70	2.18	1.96	20.80
	$\frac{\sigma}{M}\times 100$	15.70	12.10	19.80	27.60	32.10	24.20	27.80	20.70	29.80	22.40	20.0	21.20

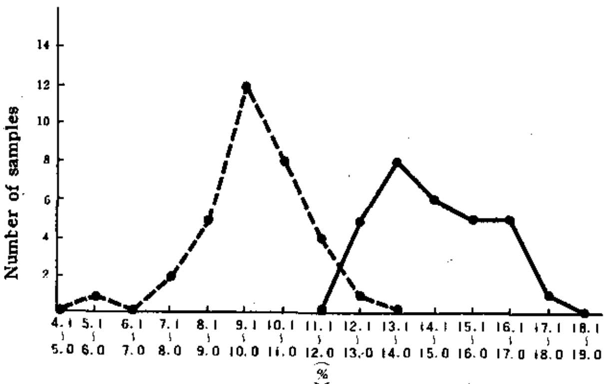

Fig. 1 Distribution of dry Weight of leaf.

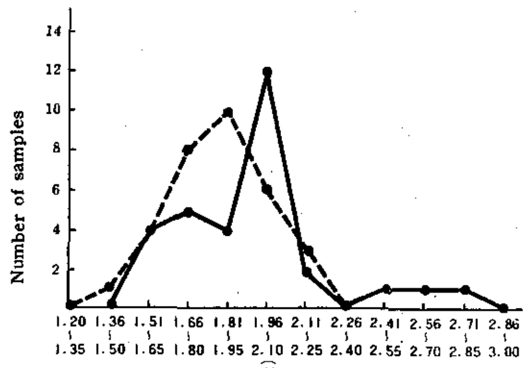

Fig. 2 Distribution of ash content in leaf.

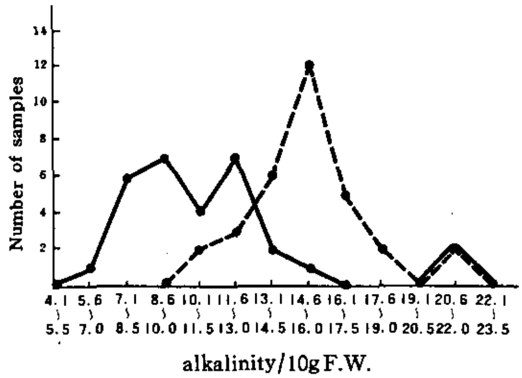

Fig. 3 Distribution of water soluble alkalinity in leaf.

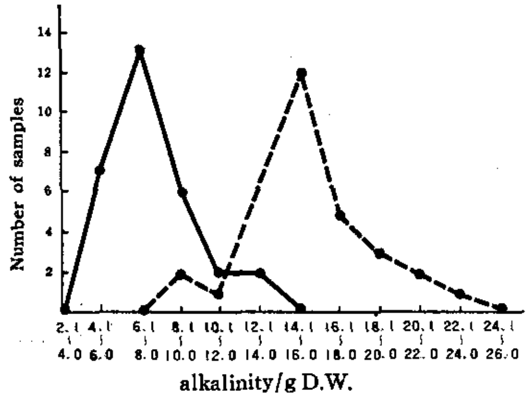

Fig. 4 Distribution of water soluble alkalinity in leaf.

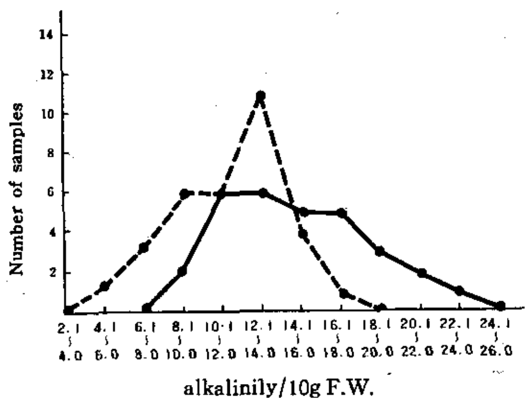

Fig. 5 Distribution of insoluble alkalinity in leaf.

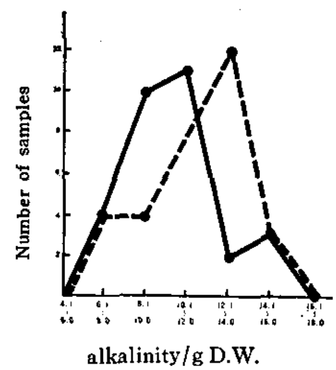

Fig. 6 Distribution of insoluble alkalinity in leaf.

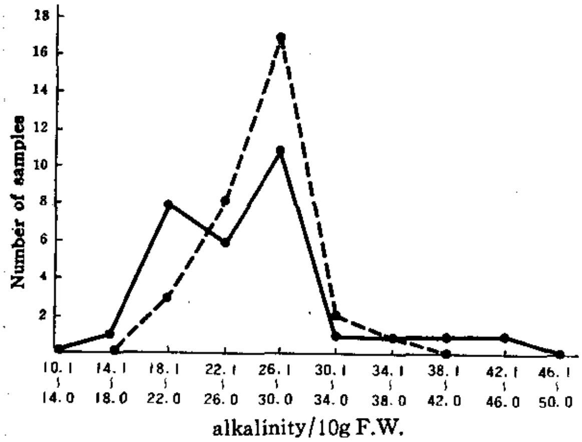

Fig. 7 Distribution of total alkalinity in leaf.

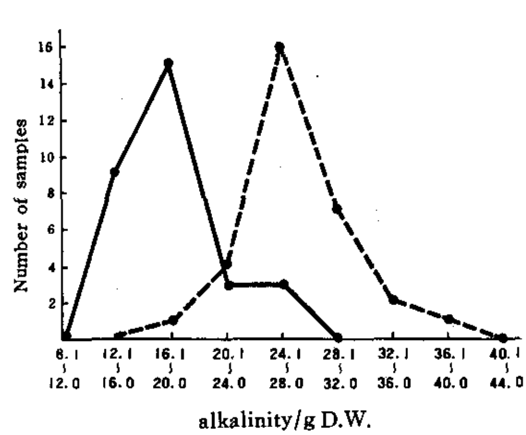

Fig. 8 Distribution of total alkalinity in leaf.

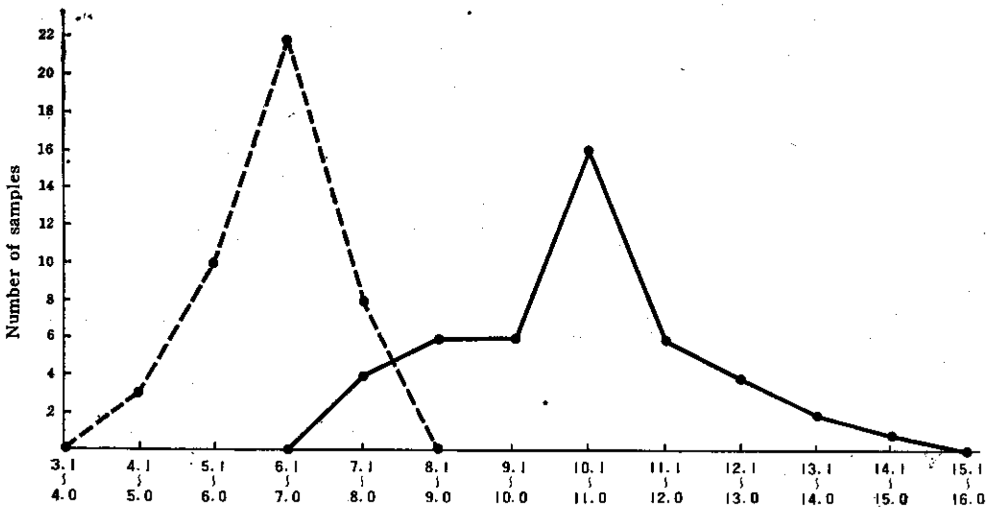

Fig. 9 Distribution of dry weight of stalk.

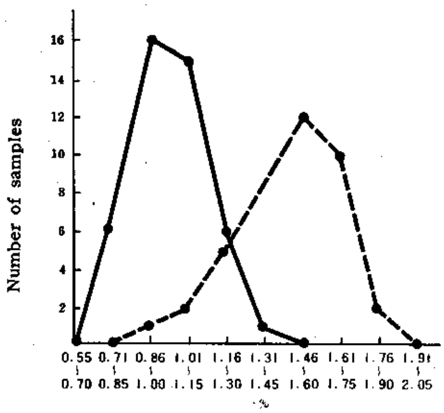

Fig. 10 Distribution of ash content in stalk.

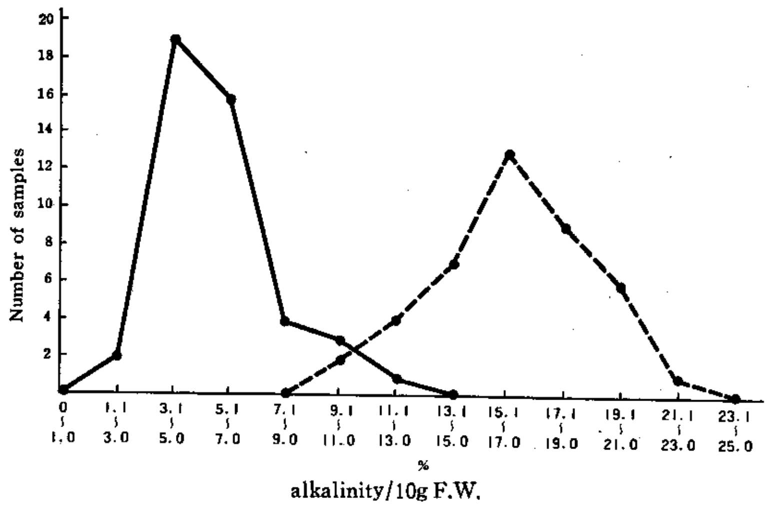

Fig. 11 Distribution of water soluble alkalinity in stalk.

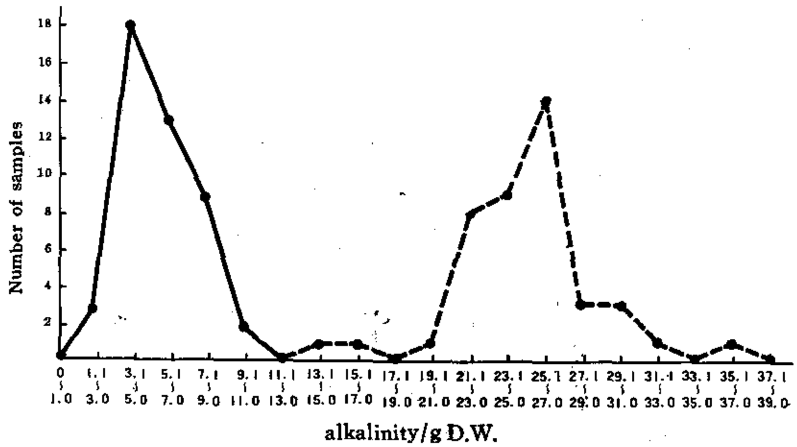

Fig. 12 Distribution of water soluble alkalinity in stalk.

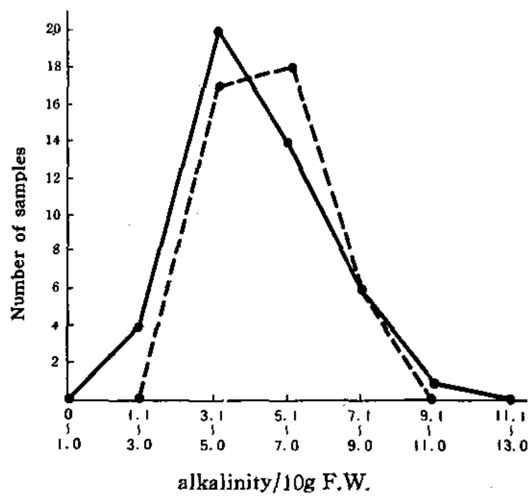

Fig. 13 Distribution of insoluble alkalinity in stalk.

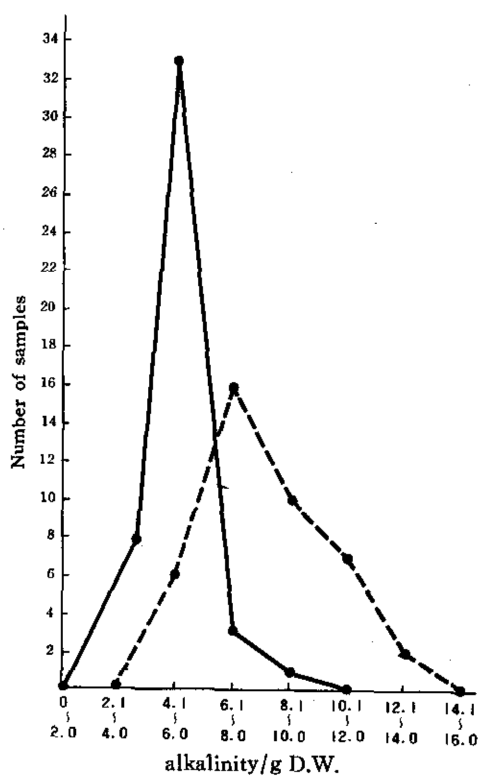

Fig. 14 Distribution of insoluble alkalinity in stalk.

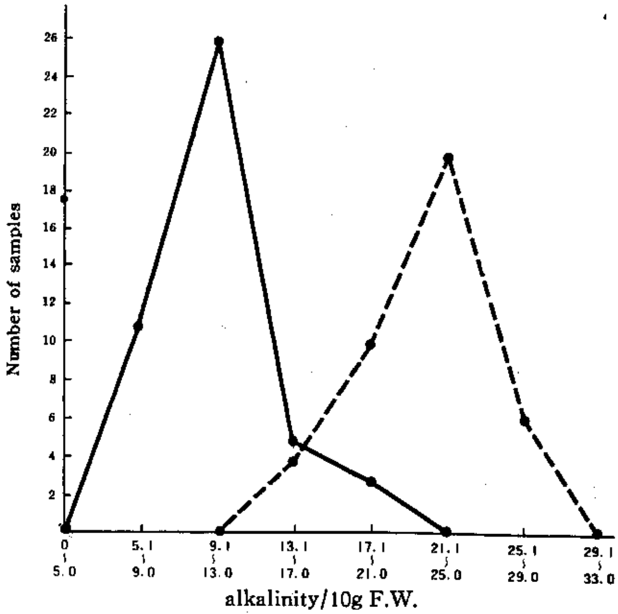

Fig. 15 Distribution of total alkalinity in stalk.

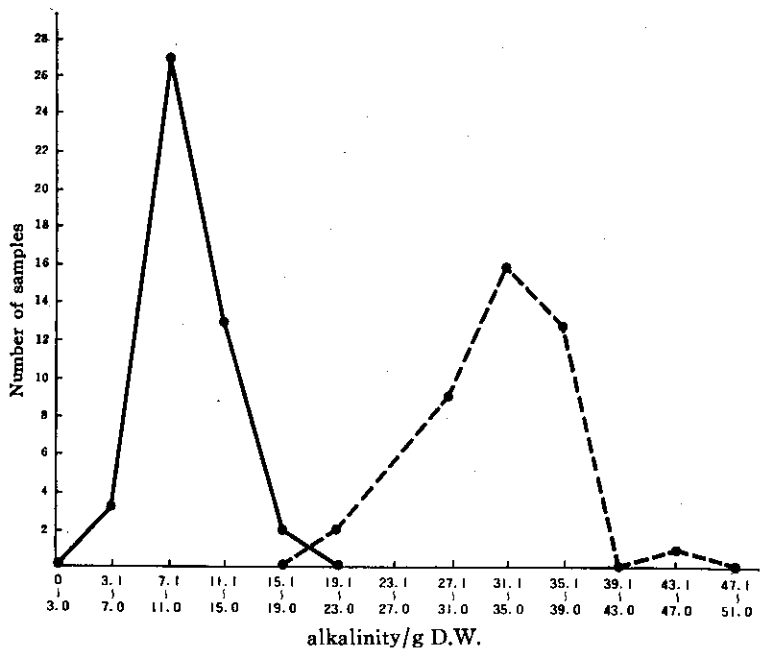

Fig. 16 Distribution of total alkalinity in stalk.

Discussion

1) Inference of mean value in population.

From the mean value of each character and its standard deviation which are presented in Tab. 1–5, those in population were calculated according to formula (1).

In this case, the confidence coefficient in the inference was assumed as 90%.

$x_1, x_2, x_3, \cdots\cdots, x_n$: values of samples (n=15)
$\bar{x}$: mean value of samples
m : mean value of distribution in population
ϵ : significance level (e=0.1)
σ : standard deviation in sample

$$P\left(\left|\frac{\sqrt{n}(\bar{x}-m)}{\sigma}\right| \leqq t_0\right) = \frac{1}{\sqrt{2\pi}}\int_{-t_0}^{t_0} e^{-\frac{x^2}{2}}dx = 1-\epsilon \quad \cdots\cdots\cdots\cdots(1)$$

The t_0 required to realize formula (1) was obtained from formula (2).

$$P\left(\left|\bar{x}-t_0\frac{\sigma}{\sqrt{n}} \leqq m \leqq \bar{x}+t_0\frac{\sigma}{\sqrt{n}}\right|\right) = 1-\epsilon \quad \cdots\cdots\cdots(2)$$

As for each character calculated by formula (2), the mean value of its population distribution is given in Tab. 6–7.

Table 6 Inference of mean value (a) and standard deviation (σ) in Population of leaf (confidence coefficient; 90%)

			Mean Value in sample (Mx)	Standard deviation in sample (S)	Mean Value in Population (a)	Standard deviation in Population (σ)
D.W. %		Vein Part	14.1	1.40	$13.44<a<14.76$	$1.120<\sigma<2.1280$
		Circumferential Part	15.1	1.47	$14.41<a<15.79$	$1.176<\sigma<2.2344$
A.W. %		Vein Part	1.91	0.258	$1.79<a<2.03$	$0.2064<\sigma<0.39216$
		Circumferential Part	2.05	0.275	$1.92<a<2.18$	$0.2200<\sigma<0.41800$
A.W./D.W. %		Vein Part	13.6	1.74	$12.78<a<14.42$	$1.392<\sigma<2.6448$
		Circumferential Part	14.0	2.12	$13.0<a<15.0$	$1.696<\sigma<3.2224$
s-A	/F.W. 10g	Vein Part	11.5	4.43	$9.42<a<13.58$	$3.544<\sigma<6.7336$
		Circumferential Part	11.0	3.48	$9.36<a<12.64$	$2.784<\sigma<5.2896$
	/D.W. g	Vein Part	8.1	2.04	$7.14<a<9.06$	$1.632<\sigma<3.1008$
		Circumferential Part	7.4	2.18	$6.38<a<8.42$	$1.744<\sigma<3.3136$
	/A.W. g	Vein Part	59.3	12.05	$53.64<a<64.96$	$9.640<\sigma<18.3160$
		Circumferential Part	52.4	11.0	$47.23<a<57.57$	$8.80<\sigma<16.720$
i-A	/F.W. 10g	Vein Part	13.2	3.16	$11.71<a<14.69$	$2.528<\sigma<4.8032$
		Circumferential Part	16.6	3.36	$15.02<a<18.18$	$2.688<\sigma<5.1072$
	/D.W. g	Vein Part	9.3	1.92	$8.40<a<10.20$	$1.536<\sigma<2.9184$
		Circumferential Part	11.3	2.17	$10.28<a<12.32$	$1.736<\sigma<3.2984$
	/A.W. g	Vein Part	68.8	14.02	$62.21<a<75.39$	$11.216<\sigma<21.3104$
		Circumferential Part	81.0	13.9	$74.47<a<87.53$	$11.12<\sigma<21.128$
t-A	/F.W. 10g	Vein Part	24.7	5.60	$22.07<a<27.33$	$4.480<\sigma<8.5120$
		Circumferential Part	27.5	5.70	$24.82<a<30.18$	$4.560<\sigma<8.6640$
	/D.W. g	Vein Part	17.4	3.78	$15.62<a<19.18$	$3.024<\sigma<5.7456$
		Circumferential Part	18.7	3.58	$17.02<a<20.38$	$2.864<\sigma<5.4416$
	/A.W. g	Vein Part	128.1	17.95	$119.66<a<136.54$	$14.360<\sigma<27.2840$
		Circumferential Part	133.3	15.78	$125.88<a<140.72$	$12.624<\sigma<23.9856$

Table 7 Inference of mean Value (a) and standard deviation (σ) in Population of stalk

(Confidence coefficient : 90%)

			Mean Value in sample (Mx)	Standard deviaton in sample (S)	Mean Value in Population (a)	Standard deviation in Population (σ)
D.W. %		top	11.30	1.41	$10.64<a<11.96$	$1.128<\sigma<2.1432$
		middle	10.03	1.33	$9.40<a<10.66$	$1.064<\sigma<2.0216$
		base	10.15	1.59	$9.40<a<10.90$	$1.272<\sigma<2.4168$
A.W. %		top	1.08	0.159	$1.01<a<1.15$	$0.1272<\sigma<0.24168$
		middle	0.96	0.119	$0.90<a<1.02$	$0.0952<\sigma<0.18088$
		base	0.99	0.120	$0.93<a<1.05$	$0.0960<\sigma<0.18240$
A.W./D.W. %		top	9.7	1.64	$8.93<a<10.47$	$1.312<\sigma<2.4928$
		middle	9.7	1.68	$8.91<a<10.49$	$1.344<\sigma<2.5536$
		base	10.1	1.99	$9.16<a<11.04$	$1.592<\sigma<3.0248$
s-A	/F.W. 10g	top	6.5	2.31	$5.41<a<7.59$	$1.848<\sigma<3.5112$
		middle	5.8	1.85	$4.93<a<6.67$	$1.480<\sigma<2.8120$
		base	5.0	1.38	$4.35<a<5.65$	$1.104<\sigma<2.0976$
	/D.W. g	top	5.9	2.02	$4.95<a<6.85$	$1.616<\sigma<3.0704$
		middle	5.9	1.85	$5.03<a<6.77$	$1.480<\sigma<2.8120$
		base	5.0	1.61	$4.24<a<5.76$	$1.288<\sigma<2.4472$
	/A.W. g	top	59.7	14.10	$53.07<a<66.33$	$11.280<\sigma<21.4320$
		middle	60.2	14.20	$53.53<a<66.87$	$11.360<\sigma<21.5840$
		base	49.5	12.0	$43.86<a<55.14$	$9.60<\sigma<18.240$
i-A	/F.W. 10g	top	6.2	1.81	$5.35<a<7.05$	$1.448<\sigma<2.7512$
		middle	4.9	1.45	$4.22<a<5.58$	$1.160<\sigma<2.2040$
		base	4.9	1.36	$4.26<a<5.54$	$1.088<\sigma<2.0672$
	/D.W. g	top	5.4	1.29	$4.79<a<6.01$	$1.032<\sigma<1.9608$
		middle	4.8	0.985	$4.34<a<5.26$	$0.7880<\sigma<1.49720$
		base	4.8	0.99	$4.33<a<5.27$	$0.792<\sigma<1.5048$
	/A.W. g	top	37.5	13.20	$31.30<a<43.70$	$10.560<\sigma<20.0640$
		middle	51.8	12.23	$46.05<a<57.55$	$9.784<\sigma<18.5896$
		base	49.3	14.70	$42.39<a<56.21$	$11.760<\sigma<22.3440$
t-A	/F.W. 10g	top	12.7	3.40	$11.10<a<14.30$	$2.720<\sigma<5.1680$
		middle	10.7	2.60	$9.48<a<11.92$	$2.080<\sigma<3.9520$
		base	9.8	2.18	$8.78<a<10.82$	$1.744<\sigma<3.3136$
	/D.W. g	top	11.3	2.72	$10.02<a<12.58$	$2.176<\sigma<4.1344$
		middle	10.6	2.24	$9.55<a<11.65$	$1.792<\sigma<3.4048$
		base	9.8	1.96	$8.88<a<10.72$	$1.568<\sigma<2.9792$
	/A.W. g	top	117.2	22.8	$106.48<a<127.92$	$18.24<\sigma<34.656$
		middle	111.9	22.0	$101.56<a<112.24$	$17.6<\sigma<33.440$
		base	98.8	20.80	$89.02<a<108.58$	$16.640<\sigma<31.6160$

Standard deviation

S : standard deviation in sample

σ : standard deviation of population distribution

L, U : values with which to estimate confidence limit of population distribution at 90%

confidence coefficient.

$\sqrt{L}\,S < \sigma < \sqrt{u}\,S$ …………(3)

The standard deviation of population distribution was estimated by formula (3) as shown in Tables 6–7. When the results shown in Tab. 6–7 are compared with those obtained in the summer spinach, it is easily recognized that there is considerable difference between them, especially in mean value and standard deviation. At 90% confidence coefficient. the confidence limit of standard deviation in population is wide at almost all the parts of winter spinach. Therefore, the homogeneity of tissue is greater in summer spinach than in winter spinach. But, as for the ratio of alkalinity to dry weight, the width of deviation is expectionally narrow is the stalk of winter spinach. The same thing is also observed in the leaf, especially at central part of leaf, and it is probably due to the fact that the winter spinach contains much more dry material than the summer spinach.

In order to confirm such as inference as that, the ratio of standard deviation in population to mean value of population was calculated with respect to each character of both winter and summer spinach.

Table 8 Value $\left(\frac{\sqrt{L}\,S}{\bar{X}-t_0\frac{\sigma}{\sqrt{n}}}\times 100 \sim \frac{\sqrt{U}\,S}{\bar{X}-t_0\frac{\sigma}{\sqrt{n}}}\times 100\right)$ in Leaf

		Part	Summer type (%)	Winter type (%)	Winter type / Summer type
Dry Weight (%)		Vein	17.6 ~ 5.80	15.9 ~ 8.4	−
		Circumferential	21.5 ~ 8.65	15.4 ~ 8.2	−
Ash Weight (%)		Vein	9.5 ~ 3.49	21.8 ~11.8	+
		Circumferential	13.6 ~ 5.41	21.9 ~11.5	+
s-A	/10g F.W.	Vein	15.8 ~ 5.14	71.5 ~37.5	+
		Circumferential	21.9 ~ 8.71	59.3 ~29.6	+
	/g D.W.	Vein	29.5 ~ 9.70	43.5 ~22.9	+
		Circumferential	40.3 ~15.9	52.0 ~27.3	+
	/g A.W.	Vein	9.4 ~ 3.07	34.3 ~18.0	+
		Circumferential	16.5 ~ 6.60	35.5 ~18.6	+
i-A	/10g F.W.	Vein	36.0 ~11.8	41.0 ~21.6	+
		Circumferential	17.9 ~ 7.10	34.0 ~17.9	+
	/g D.W.	Vein	55.9 ~18.8	34.7 ~18.3	−
		Circumferential	17.9 ~ 6.58	32.0 ~17.2	+
	/g A.W.	Vein	40.5 ~13.4	35.6 ~19.7	−
		Circumferential	14.7 ~ 5.82	28.5 ~14.9	+
t—A	/10g F.W.	Vein	10.5 ~ 2.90	38.7 ~20.3	+
		Circumferential	11.0 ~ 4.40	34.7 ~18.4	+
	/g D.W.	Vein	33.3 ~ 9.18	36.6 ~19.3	+
		Circumferential	17.6 ~ 7.00	31.9 ~16.9	+
	/g A.W.	Vein	17.5 ~ 4.81	22.8 ~12.0	+
		Circumferential	11.8 ~ 4.65	19.0 ~10.0	+

Table 9 Value $\left(\frac{\sqrt{L}S}{\bar{X}-t_0\frac{\sigma}{\sqrt{n}}}\times 100 \sim \frac{\sqrt{U}S}{\bar{X}-t_0\frac{\sigma}{\sqrt{n}}}\times 100\right)$ in Stalk.

		Part	Summer type (%)	Winter type (%)	Winter type / Summer type
Dry Weight (%)		top	9.35～5.02	20.0～10.6	+
		middle	10.2～4.05	21.3～11.3	+
		base	16.0～7.63	25.5～13.6	+
Ash Weight (%)		top	10.8～5.61	23.8～12.8	+
		middle	19.0～7.5	20.0～11.1	+
		base	15.5～7.15	19.4～10.8	+
s-A	/10g F.W.	top	16.6～8.50	64.5～20.0	+
		middle	21.3～8.41	57.2～30.0	+
		base	18.2～8.4	48.3～25.3	+
	/g D.W.	top	15.8～8.1	62.1～32.7	+
		middle	17.2～6.8	55.8～29.4	+
		base	15.0～6.9	58.0～30.4	+
	/g A.W.	top	7.45～3.80	40.5～21.2	+
		middle	7.95～3.15	40.4～21.2	+
		base	6.00～2.84	41.7～21.9	+
i-A	/10g F.W.	top	30.3～14.6	51.3～27.1	+
		middle	47.8～17.4	52.1～27.5	+
		base	26.2～12.2	48.6～23.7	+
	/g D.W.	top	30.6～14.8	41.0～21.6	+
		middle	39.4～14.4	34.5～18.2	−
		base	27.9～13.0	34.6～18.2	+
	/g A.W.	top	27.5～13.3	64.0～33.6	+
		middle	38.9～14.2	40.3～21.1	+
		base	30.5～14.1	53.0～27.8	+
t-A	/10g F.W.	top	12.8～6.6	46.6～24.5	+
		middle	19.6～7.15	41.7～22.0	+
		base	12.2～5.61	37.9～19.8	+
	/g D.W.	top	13.6～6.93	41.1～21.2	+
		middle	14.6～5.35	35.6～18.7	+
		base	11.9～5.50	33.6～17.8	+
	/g A.W.	top	8.9～4.55	32.5～17.2	+
		middle	10.6～3.86	33.0～17.4	+
		base	7.68～3.51	35.5～18.6	+

$\bar{X}-t_0\frac{\sigma}{\sqrt{n}}$ was adopted for convenience as mean value of population. The results are given in Tab. 8–9. As shown in Tab. 8–9, $\sqrt{L}S/\bar{X}-t_0\frac{\sigma}{\sqrt{n}} \sim \sqrt{U}S/\bar{X}-t_0\frac{\sigma}{\sqrt{n}}$ of summer spinach is small for almost all characters, and therefore, it is clear that the summer material is more homogeneous.

2) Comparison of winter spinach with summer spinach resspect of mean value of each character.

The mean value of each character given in Tab. 1–5 are somewhat different from the results reported previously[1]. To test the significance of these differences, t-value was calculated by the following formula and the differences were estimated respectively at 5% and 1% significance level.

M_s : mean value of summer sample
M : number of summer sample
M_w : mean value of winter sample
N : number of winter sample
$x_1, x_2, \cdots\cdots x_i$: value of summer sample
$y_1, y_2, \cdots\cdots y_i$: value of winter sample
ω : $\sqrt{\dfrac{\Sigma(x_i-M_s)^2+\Sigma(y_i-M_w)^2}{M+N-2}}$

$$t=\frac{(M_w-M_s)}{\omega}\sqrt{\frac{MN}{M+N}}\cdots\cdots\cdots\cdots(4)$$

By using the t calculated by formula (4) and the table of t, the test of significance was done with the results given in Tab. 10–14. As these tables show there are remarkable difference in the dry weight of the stalk and leaf ana their s-A.

Table 10 Difference between summer and winter type as for each character in Circumferential Part of leaf.

		Type	Nmber of samples	Mean	Significncea level at 5%	at 1%
D.W. %		S	8	10.5	+	+
		W	15	15.0		
A.W. %		S	8	1.91	–	–
		W	15	2.05		
s-A	/F.W. 10g	S	8	14.6	+	–
		W	15	11.0		
	/D.W. g	S	8	12.8	+	+
		W	15	7.4		
	/A.W. g	S	8	75.8	+	+
		W	15	52.4		
i-A	/F.W. 10g	S	8	13.2	+	–
		W	15	16.6		
	/D.W. g	S	8	13.3	+	–
		W	15	11.3		
	/A.W. g	S	8	69.1	+	–
		W	15	81.0		
t-A	/F.W. 10g	S	8	27.4	–	–
		W	15	27.5		
	/D.W. g	S	8	26.6	+	+
		W	15	18.7		
	/A.W. g	S	8	143.4	–	–
		W	15	133.3		

S : Summer type (–) No difference
W: Winter type (+) With differece

Table 11 Difference between summer and winter type as for each Character in vein part of leaf.

		Type	Number of samples	Mean	Significance level at 5%	at 1%
D.W. %		S	6	9.4	+	+
		W	15	14.1		
A.W. %		S	7	1.82	–	–
		W	15	1.91		
s-A	/F.W. 10g	S	6	16.9	+	–
		W	15	11.5		
	/D.W, g	S	6	18.7	+	+
		W	15	8.1		
	/A.W. g	S	6	92.0	+	+
		W	15	59.3		
i-A	/F.W. 10g	S	6	9.2	+	–
		W	15	13.2		
	/D.W, g	S	6	10.0	–	–
		W	15	9.3		
	/A.W. g	S	6	51.1	+	–
		W	15	68.8		
t-A	/F.W. 10g	S	5	25.9	–	–
		W	15	24.7		
	/D.W. g	S	5	28.2	+	+
		W	15	17.4		
	/A.W. g	S	5	142.6	–	–
		W	15	128.1		

S : Summer type (–) No difference
W: Winter type (+) With difference

Table 12 Difference between summer and winter type as for each Character in top part of stalk.

		Type	Number of samples	Mean	Significance level at 5%	Significance level at 1%
D.W. %		S	15	7.1	+	+
		W	15	11.3		
A.W. %		S	14	1.60	+	+
		W	15	1.08		
s-A	/F.W. 10g	S	14	17.4	+	+
		W	15	6.5		
	/D.W. g	S	14	24.8	+	+
		W	15	5.9		
	/A.W. g	S	14	108.1	+	+
		W	15	59.7		
i-A	/F.W. 10g	S	12	6.5	−	−
		W	15	6.2		
	/D.W. g	S	12	9.5	+	+
		W	15	5.4		
	/A.W. g	S	12	40.9	−	−
		W	15	37.5		
t-A	/F.W. 10g	S	14	23.8	+	+
		W	15	12.7		
	/D.W. g	S	14	33.8	+	+
		W	15	11.3		
	/A.W. g	S	14	147.7	+	+
		W	15	117.2		

S : Summer type (−) No difference
W: Winter type (+) With differnce

Table 13 Difference between summer and winter type as for each Character in Middle part of stalk.

		Type	Number of samples	Mean	Significance level at 5%	Significance level at 1%
D.W. %		S	8	6.4	+	+
		W	15	10.0		
A.W. %		S	8	1.47	+	+
		W	15	0.96		
s-A	/F.W. 10g	S	8	16.6	+	+
		W	15	5.8		
	/D.W. g	S	8	26.1	+	+
		W	15	5.9		
	/A.W. g	S	8	112.1	+	+
		W	15	60.2		
i-A	/F.W. 10g	S	7	4.9	−	−
		W	15	4.9		
	/D.W. g	S	7	7.8	+	+
		W	15	4.8		
	/A.W. g	S	7	33.9	+	−
		W	15	51.8		
t-A	/F.W. 10g	S	7	22.5	+	+
		W	15	10.7		
	/D.W. g	S	7	35.1	+	+
		W	15	10.6		
	/A.W. g	S	7	148.9	+	+
		W	15	111.9		

S : Summer type (−) No difference
W: Winter type (+) With difference

Table 14 Difference between summer and Winter type as for each character in base part of stalk.

		Type	Number of samples	Mean	Significance level at 5%	Significance level at 1%
D.W. %		S	12	6.2	+	+
		W	15	10.2		
A.W. %		S	11	1.54	+	+
		W	15	0.99		
s-A	/F.W. 10g	S	11	16.4	+	+
		W	15	5.0		
	/D.W. g	S	11	25.5	+	+
		W	15	5.0		
	/A.W. g	S	11	98.3	+	+
		W	15	49.5		
i-A	/F.W. 10g	S	11	4.2	−	−
		W	15	4.9		
	/D.W. g	S	11	6.7	+	+
		W	15	4.8		
	/A.W. g	S	11	25.9	+	+
		W	15	49.3		
	/F.W. 10g	S	11	20.1	+	+
		W	15	9.8		

t-A	/D.W. g	S W	11 15	32.5 9.8	+	+
	/A.W. g	S W	11 15	125.5 98.8	+	+

S : Summer type (−) No difference
W : Winter type (+) With difference

It has been proved that those differences are significiant for almost all the characters except the ash content of the leaf. The fact that the s-A is low in the winter material seems to be interesting from the viewpoint of the metabolic physiology of the plant.

There was no significant difference in ash content of the leaf between summer and winter spinach. Therefore, the decrease in the ratio of water-soluble ash reciprocally resulted in the increase of the ratio ofwater-insoluble ash. On the other hand, the stalk of winter spinach was lower in ash content than that of summer spinach. Consequently, the s-A was also lower in the former. There was no significant difference between the i-A and fresh weight. Hence, the change in ash content of the stalk does not have so much to do with the i-A, as the change in s-A.

This fact corresponds with the correlation coefficient between alkalinity and ash content, as well be described later.

Such a difference in ash content of the leaf and stalk and the difference in the relative amount of what composes the ash are indicative of the physiological properties of the plant.

3) Comparison of mean values obtained from divided parts of leaf and stalk.

The significance of the mean value of each character was tested in the divided parts of leaf and stalk.

In the case of the leaf ; t was estimated by the equation (4′)

$$t=\frac{(M_x-M_y)}{\omega}\sqrt{\frac{MN}{M+N}} \quad \cdots\cdots(4')$$

M_x : mean value of samples of vein part
M : number of samples of vein part
M_y : mean value of samples of remainder
N : number of samples of remainder

The value of t calculated by (4′) was judged by the table of t.

In the case of the stalk ; The top, middle, and base part of the stalk were respectively regarded as an inter-class factor. The inter-class variate, intra-class variate, and variance ratio were calculated by the following formulas.

Inter-class variate $S_b=\sum_{i=1}^{3}(m_i-M)^2\times 15 \cdots\cdots(5)$

Intra-class variate $S_w=\sum_{i=1}^{3}\sum_{j=1}^{15}(m_i-x_{ij})^2 \cdots\cdots(6)$

Inter-class variance $U^2=\frac{S_b}{(3-1)} \cdots\cdots(7)$

Intra-class variance $V^2=\frac{S_w}{(45-3)} \cdots\cdots(8)$

Variance ratio $F^2=\frac{U^2}{V^2} \cdots\cdots(9)$

Class	top	middle	base	
Value measured Mean	x_{1j} m_1	x_{2j} m_2	x_{3j} m_3	 total mean M

The F calculated by the above equation was checked with the table of F-distribution.

The results are shown in Tab. 15–16. As in Tab. 15, the vein and the remainder showed a significant difference in the value of i-A. In the summer spinach, on the contrary, this value did not show any significant difference. As given in Tab. 16, in the stalk, the dry weight of the top part is heavier than those of the other parts. This difference was recognized as significant. The ratio of s-A to fresh weight was not significant. But the i-A and t–A of the top were both higher than those of the base part, and the difference was significant.

In general, it was observed that not only

Table 15 Comparison of mean values of each character in each part of the leaf.

		Kind	Samples	Mean	Significance level at 5%	Significance level at 1%
D.W. %		V	15	14.1	−	−
		C	15	15.1		
A.W. %		V	15	1.91	−	−
		C	15	2.05		
s-A	/F.W. 10g	V	15	11.5	−	−
		C	15	11.0		
	/D.W. g	V	15	8.1	−	−
		C	15	7.4		
	/A.W. g	V	15	59.3	−	−
		C	15	52.4		
i-A	/F.W. 10g	V	15	13.2	+	+
		C	15	16.6		
	/D.W. g	V	15	9.3	+	−
		C	15	11.3		
	/A.W. g	V	15	68.8	+	−
		C	15	81.0		
t-A	/F.W. 10g	V	15	24.7	−	−
		C	15	27.5		
	/D.W. g	V	15	17.4	−	−
		C	15	18.7		
	/A.W. g	V	15	128.1	−	−
		C	15	133.3		

V : Vein Part　　(−) No difference

C : Circumferential Part　　(+) With difference

Table 16 Comparison of mean Values of each character in each part of the stalk.

		Mean Value			Intra-class		Inter-class		Variance vatio	at 5% Significance level
		Top	Middle	base	Variate (S_w)	Variance (V^2)	Variate (S_b)	Variance (U^2)	$\left(F=\frac{U^2}{V^2}\right)$	
D.W. %		11.30	10.03	10.15	94.52	2.25	14.75	7.37	3.27	+
A.W. %		1.08	0.96	0.99	0.81	0.02	0.12	0.06	3.03	−
D.W./A.W %		9.7	9.7	10.1	142.48	3.39	1.65	0.83	0.24	−
s-A	/F.W. 10g	6.5	5.8	5.0	160.25	3.82	16.90	8.45	2.21	−
	/D.W. g	5.9	5.9	5.0	150.62	3.59	8.10	4.05	1.13	−
	/A.W. g	59.7	60.2	49.5	8169.61	194.51	1093.95	546.98	2.81	−
i-A	/F.W. 10g	6.2	4.9	4.9	108.10	2.57	16.95	8.48	3.30	+
	/D.W. g	5.4	4.8	4.8	54.13	1.29	3.60	1.80	1.39	−
	/A.W. g	37.5	51.8	49.3	9622.43	229.11	1749.90	874.95	3.82	+
t-A	/F.W. 10g	12.7	10.7	9.8	345.92	8.24	66.15	33.08	4.01	+
	/D.W. g	11.3	10.6	9.8	243.96	5.81	16.95	8.48	1.46	−
	/A.W. g	117.2	111.9	98.8	21445.24	510.60	2691.30	1345.65	2.64	−

the alkali content, but also almost all the characters increased gradually from the base part of the stalk to the remainder of the leaf. This is, the concentration of substance in the plant may increase continuously from the root to the top of the leaf.

4) Comparison of water soluble alkalinity with insoluble alkalinity.

Of all the characters of winter and summer spinach, the most noteworthy one consists in the difference in the ratio of s-A to i-A. In the summer spinach s-A was higher than i-A for the stalk and leaf.

This tendancy was the strongest at the base part of the stalk and gradually weakened in the other : base→middle→top→vien →circumferential part of leaf. In winter spinach, on the other hand, the ratio of s-A to i–A was lower than that of the summer material. Especially in the leaf, i–A was higher than s–A. In the winter spinach, this value was maximum at the middle part of the stalk and gradually decreased in the or der of top and base of stalk, vein and remainder of leaf.

The ratio of s–A to i–A was also estimated in each part of the leaf and stalk. These results are given in Tab. 17. As shown in Tab. 17, it is evident that the content of alkalinity is strongly affected by temperature conditions.

Table 17 Ratio of water-soluble alkalinity to water-insoluble alkalinity.

		Alkalinity/F.W. 10g		Alkalinty/D.W. g		Alkalinity/A.W. g	
		S	W	S	W	S	W
Leaf	Vein Part	1.84	0.87	1.87	0.87	1.80	0.86
	Circumferential Part	1.10	0.66	0.96	0.65	1.09	0.65
Stalk	Top	2.68	1.04	2.60	1.09	2.65	1.04
	Middle	3.40	1.18	3.35	1.23	3.31	1.16
	Base	3.90	1.02	3.82	1.04	3.80	1.00

5) Correlation coefficient between alkalinity and ash content.

In order to elucidate the relation between ash content and alkalinity, their correlation coefficients were calculated by the following formula (10).

$$\text{Ash content or alkalinity/A.W.g} : x_1\ x_2 \cdots\cdots x_{15}\quad \bar{x}=\frac{1}{15}\sum_{i=1}^{15} x_i$$

$$\text{alkalinity/F.W.g} : y_1\ y_2 \cdots\cdots y_{15}\quad \bar{y}=\frac{1}{15}\sum_{i=1}^{15} y_i$$

$$r=\frac{\sum_{i=1}^{15}(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\left(\sum_{i=1}^{15}(x_i-\bar{x})^2\right)\left(\sum_{i=1}^{15}(y_i-\bar{y})^2\right)}} \cdots\cdots\cdots\cdots (10)$$

The correlation coefficients between the ash content and the ratio of alkalinity to F.W. 10g in the stalk and leaf are given in Tab. 18–19, and the results obtained in the summer spinach are also given there. As shown in Tab. 18, the correlation coefficients between s–A/fresh weight, i–A/fresh weight, and t–A/fresh weight were respectively higher in the circumferential part than in the vien part of the leaf. The same tendency was also observed in the stalk, e. g. the above-mentioned correlation coefficients increased gradually in the order of base to top.

Table 18 Correlation coefficient between ash content and alkalinity/F.W.10g in the leaf.

x	y	Part	Correlation coefficient (r)	
			W	S
A.W. %	s–A /F.W.10g	Vein	0.66	0.93
		Circumferential	0.77	0.90
	i–A /F.W.10g	Vein	0.56	0.31
		Circumferential	0.60	0.73
	t–A /F.W.10g	Vein	0.52	0.87
		Circumferential	0.87	0.91

Table 19 Correlation coefficient between ash content and alkalinity/F.W.10g in the stalk.

x	y	Part	Correlation Coefficient (r)	
			W	S
A.W. %	s–A /F.W.10g	top	0.74	0.91
		middle	0.68	0.91
		base	0.59	0.88
	i–A /F.W.10g	top	0.40	0.00
		middle	0.12	0.60
		base	0.06	0.14
	t–A /F.W.10g	top	0.73	0.94
		middle	0.55	0.99
		base	0.42	0.89

Table 20 Correlation coefficient between alkalinity/F.W.10g and alkalinity/A.W.g in the leaf.

	Part	Correlation coefficient(r)	
		W	S
s-A	Vein	0.72	0.92
	Circumferential	0.65	0.71
i-A	Vein	0.82	0.97
	Circumferential	0.77	0.90
t-A	Vein	0.79	0.92
	Circumferential	0.75	0.91

Table 21 Correlation coefficient between alkalinity/F.W.10g and alkalinity/A.W.g in the stalk.

	Part	Correlation coefficient(r)	
		W	S
s-A	top	0.93	0.76
	middle	0.92	0.77
	base	0.89	0.20
i-A	top	0.85	0.95
	middle	0.92	0.92
	base	0.91	0.91
t-A	top	0.78	0.46
	middle	0.82	0.72
	base	0.83	−0.34

On the contrary, the tendency was not so clearly recognized in the summer spinach. The correlation coefficient between alkalinity /fresh weight, and alkalinity/ash weight in the leaf and stalk is given in Tab. 20–21. The results obtained in summer spinach are also cited for comparison. From the results given in Tab. 20, it is evident that the correlation coefficient between alkalinity/F.W. 10g and alkalinity/A.W.g in the vein is greater than that in circumferential part. The similar tendancy was observed in the summer material. It is inferred from Tab. 20 that the correlation between alkalinity/F.W.g and alkalinity/A.W.g is higher in winter spinach than in summer spinach, and that there are very significant correlations in all the parts of the material and also in regard to s–A, i–A and t–A. Winter spinach differs from summer spinach in these two respects.

In the stalk, as pointed out in paragraph 2) there were certain correlations between s–A and ash content, but no correlation between i–A and ash content. This point seems to be a distinctive feature of the stalk.

6) Inference of correlation coefficients in population and comparison of their values in winter and summer material.

The correlation coefficients mentioned above were also estimated in population by the following formula, in order to elucidate how wide and how significant it is in population.

With the confidence coefficient of correlation coefficient in population : 90%

r : correlation coefficient in samples

r_ρ : correlation coefficient in population

$$Z=\frac{1}{2}\log e\ \frac{1+r}{1-r} \quad \cdots\cdots(11)$$

$$Z_\rho=\frac{1}{2}\log e\ \frac{1+r_\rho}{1-r_\rho} \quad \cdots\cdots(12)$$

$$Z+\frac{t}{\sqrt{n-3}}>Z_\rho>Z-\frac{t}{\sqrt{n-3}} \quad \cdots\cdots(13)$$

t : obtained from Student's t-distribution table (1.64 at 90% confidence coefficient).

The significance of the correlation coefficient was estimated by formula (14).

$$t=\frac{r}{\sqrt{1-r^2}}\sqrt{n-2} \quad \cdots\cdots(14)$$

To express the results, it was assumed that when the value of t calculated by (14) is higher than 5% in the column corresponding to freedom N=2 of Table t, it was significant, and that when the value t is higher than 1%, it was very significant. The results are shown in Tab. 22–25. As shown in Tab. 22–25 it was clarified that each of the correlations given in the above paragraph was also maintained in population.

The correlation coefficients of some of the

Table 22 Inference of correlation coefficient between A.W.% and alkalnity/F.W.10g in population of the leaf.

x	y	Part	r	Correlation coefficient in population (r_ρ)	Significance*
A. W. %	s-A/F.W. 10g	Vein	0.66	0.855~0.314	++
		Circumferential	0.77	0.904~0.497	++
	i-A/F.W. 10g	Vein	0.56	0.806~0.164	+
		Circumferential	0.60	0.826~0.222	+
	t-A/F.W. 10g	Vein	0.52	0.784~0.105	+
		Circumferential	0.87	0.949~0.700	++

* – No significance
\+ Significant
++ Very significant

Table 23 Inference of correlation coefficient between A.W.% and alkalinity/F.W.10g in population of the stalk.

x	y	Part	r	Correlation coefficient in population (r_ρ)	Significance*
A. W. %	s-A/F.W. 10g	top	0.74	0.891~ 0.443	++
		middle	0.68	0.862~ 0.342	++
		base	0.59	0.818~ 0.202	+
	i-A/F.W. 10g	top	0.40	0.723~−0.055	–
		middle	0.11	0.528~−0.348	–
		base	0.06	0.490~−0.393	–
	t-A/F.W. 10g	top	0.73	0.886~ 0.427	++
		middle	0.55	0.800~ 0.144	+
		base	0.42	0.728~−0.025	–

* – No significance
\+ Significant
++ Very significant

Table 24 Inference of correlation coefficient between alkalinity/F.W.10g and alkalinity/A.W.g in population of the leaf.

x	y	Part	r	Correlation coefficient in population (r_ρ)	Significance*
s-A/F.W. 10g	alkalinity/A.W.g	Vein	0.72	0.882~0.412	++
		Circumferental	0.65	0.849~0.295	++
i-A/F.W. 10g		Vein	0.82	0.927~0.594	++
		Circumferental	0.77	0.904~0.497	++
t—A/F.W. 10g		Vein	0.79	0.913~0.535	++
		Circumferental	0.75	0.897~0.466	++

* – No significant
\+ Significant
++ Very significant

Table 25 Inference of correlation coefficient between Alkalinity/F.W.10g and alkalinity/A.W.g in population of the stalk.

x	y	part	r	Correlation coefficient in population (r_p)	Significance*
s-A/F.W. 10g	alkalinity/A.W.g	top	0.93	0.973~0.830	++
		middle	0.92	0.968~0.804	++
		base	0.89	0.955~0.737	++
i-A/F.W. 10g		top	0.85	0.940~0.656	++
		middle	0.92	0.968~0.803	++
		base	0.91	0.964~0.786	++
t-A-F.W. 10g		top	0.78	0.908~0.510	++
		middle	0.82	0.928~0.595	++
		base	0.83	0.930~0.607	++

* − No significance
\+ significant
++ Very significant

characters are somewhat different in the winter and the summer material. The significance of these differences was checked. For this purpose, the limit of correlation coefficient with confidence coefficient in population at 90% was estimated for both summer and winter material. When the limit values did not overlap, it was thought that the differ

Table 26 Comparison of winter type and summer type in regard to correlation coefficient between ash content and alkalinity in population of the leaf.

x	y	Part	Correlation coefficient in population		Difference
			S	W	
A. W. %	s-A/F.W. 10g	Vein	0.989~ 0.611	0.855~0.314	No
		Circumferential	0.980~ 0.572	0.904~0.497	No
	i-A/F.W. 10g	Vein	0.814~−0.462	0.806~0.164	No
		Circumferential	0.922~ 0.254	0.826~0.222	No
	t-A/F.W. 10g	Vein	0.979~ 0.363	0.784~0.105	No
		Circumferential	0.978~ 0.658	0.949~0.700	No

Table 27 Comparison of winter type and summer type in regard to correlation coefficient between ash content and alkalinity in population of the stalk.

x	y	Part	Correlation coefficient in population		Difference
			S	W	
A. W. %	s-A/F.W. 10g	top	0.965~ 0.774	0.891~ 0.443	No
		middle	0.978~ 0.659	0.862~ 0.342	No
		base	0.971~ 0.572	0.818~ 0.202	No
	i-A/F.W. 10g	top	0.478~−0.478	0.732~−0.055	No
		middle	0.979~−0.139	0.528~−0.348	No
		base	0.641~−0.446	0.490~−0.393	No
	t-A/F.W.10g	top	0.980~ 0.831	0.886~ 0.427	No
		middle	1.00 ~ 0.935	0.800~ 0.144	with
		base	0.967~ 0.664	0.728~−0.025	No

Table 28 Comparison of winter type and summer type in regard to correlation coefficient between alkalinity/F.W.10g and alkalinity/A.W.g in population of the leaf.

x	y	Part	Correlation coeffieient in population		Difference
			S	W	
s-A/F.W. 10g	alkalinity/A.W. g	Vein	0.984~0.641	0.882~0.412	No
		Circumferential	0.905~0.254	0.849~0.295	No
i-A/F.W. 10g		Vein	0.993~0.834	0.927~0.594	No
		Circumferential	0.970~0.696	0.904~0.497	No
t-A/F.W. 10g		Vein	0.962~0.319	0.913~0.535	No
		Circumferential	0.979~0.670	0.897~0.466	No

Table 29 Comparison of winter type and summer type in regard to correlation cocfficient between alkalinity/F.W.10g and alkalinity/A.W.g in population of the stalk.

x	y	Part	Correlation coefficient in population		Difference
			S	W	
s-A/F.W. 10g	alkalinity/A.W. g	top	0.892~ 0.483	0.973~0.830	No
		middle	0.935~ 0.345	0.968~0.804	No
		base	0.617~-0.310	0.955~0.737	With
i-A/F.W. 10g		top	0.981~ 0.872	0.940~0.656	No
		middle	0.982~ 0.696	0.968~0.803	No
		base	0.969~ 0.726	0.964~0.786	No
t-A/F.W. 10g		top	0.740~ 0.050	0.908~0.510	No
		middle	0.927~ 0.168	0.928~0.595	No
		base	0.159~-0.686	0.930~0.607	With

ence of the correlation coefficients was significant. These results are shown in Tab. 26–29. As given in Tab. 26–29, there is no significant difference in the correlation coefficient between A.W.% and alkalinity/F.W.10g in both winter and summer material. Thit is, the basic relation that the ash content controls the alkalinity in an organism is common in both types of spinach. In the base part of the stalk, the correlation coefficient between alkalinity/F.W.10g and alkalinity/A.W.g was higher in winter material in respect to s-A and t-A, and that was a significant difference from summer material.

From the results described above, in the base part of the stalk it is expected that there are some differences in their physiological properties. But the details remain to be made clear by further experiments. On the whole. it is inferred that there is no significant difference in basic characters between the stalk of winter material and that of summer material.

Conclusion

By using the spinach harvested in winter, its ash-content, dry weight, and alkalinity were determined and they were compared with the results obtained in the summer spinach. As a results the following points were clarified.

1. Each character of winter spinace has a larger deviation than that of summer spinach, and therefore the homogeneity of the

former is low.

2. As for dry weight, winter material is heavier than summer material. Ash content is about the same in the leaf, but somewhat low in the stalk of the former.

3. In the leaf of winter spinach, water-soluble alkalinity decreases and insoluble-alkalinity increases, as compared with summer spinach. In the stalk of winter spinach, water-soluble alkalinity decreases, but insoluble-alkalinity does not increase as in summer spinach.

4. In winter material, the ratio of water-soluble alkalinity to water-insoluble alkalinity is low. On the contorary, in summer material this ratio is high.

5. As for each character, there is a certain continuous decline in the order : base of stalk→middle→ top → vein → circumferential part of leaf.

6. In the leaf of winter spinach, water-soluble, water-insoluble, and total alkalinity have respectivly a positive correlation with ash content. In the stalk, there is correlation between water-soluble and total alkalinity on the one hand and ash content on the other, but there is no correlation between water-insoluble alkalinity and ash content. These characters are also found in summer spinach.

7. In the leaf of winter spinach, each alkalinity has a high correlation coefficient to alkalinity/A.W.g. In the stalk of winter spinach, there is a high correlation among the various types of alkalinity.

8. The correlation coefficients in population are estimated. As a result, it is shown that their correlation coefficients have no significant difference in both materials. Therefore, it is inferred that the basic factors dominating the alkalinity of plant are the same in both materials.

Literature

1) H. Imamiya and H. Teraoka, Sci. Rep. of Hokusei women's Junior College, 9, 10 (1963).