

II.—The Carotene Content of Some South African Feeds.

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IN a previous publication (1935), it was stated, that a Vitamin-A deficiency probably exists under ranching conditions during the dry periods of the year in South Africa. There are indications of such a deficiency due to the low carotene content of some mature veld grasses, which were analyzed. To test the existence of such a shortage, it was considered important that analyses of grass samples from the veld or under veld conditions, be carried out.

Since the preservation and conservation of grass hays for the feeding of animals in the dry periods in the summer-rainfall areas is not a general practice, the cattle on ranches have to seek their feed on the veld. Due, probably, to high temperatures in the summer and even in autumn, pasture grasses become mature very soon and the result is a rapid decline in the carotene content of even the best nutritional grasses.

Hart and Guilbert (1933) have found that, under ranching conditions in California, cattle suffer from a Vitamin-A deficiency during the dry spells. When the dry seasons were unusually prolonged the result was not only an actual shortage of carotene intake, but as a result poor growth, failure in reproduction, abortions, weak and sickly offspring amongst range cattle. Experimentally these facts were established by them in their classical work (1937) on cattle, swine and sheep, on low levels of Vitamin-A in rations. Minimum daily requirements were thus found and given as 25-30 micrograms carotene per Kilogram body weight. Excellent growth could still be obtained at these low levels of carotene (or Vitamin A), intake, but the storage over a long period was small.

An excellent study can thus be carried out in conjunction with a general survey of South African veld grasses, and valuable information so obtained, concerning the carotene content of our well-known grasses as an indication of a deficiency that may or may not exist.

The years 1932 and 1933 were exceedingly dry periods with no rain for months to bring about the onset of new growth of grass. During June, July, and August, 1932, there was no rain at all.

and again May (June, 0·23 inches), July, August, September, and October, 1933, were dry months. Unluckily this work was begun only in 1935 and thus a very important period was missed. It is hoped that with the occurrence of such a period again, the necessary information will be obtained.

To obtain, as preliminary work, an indication of the carotene content of some important and indigenous grasses, the writer decided to cut from established experimental plots, monthly samples and analyse them. These grasses when once established, were left to grow under natural climatic conditions.

The plots referred to here are described in detail by J. G. Louw (1938) and the grasses selected for monthly cuttings over the period of a year were: *Chloris gayana*, *Digitaria eriantha* variety *Stolonifera*, *Cenchrus ciliaris*, *Eragrostis plana*, *Panicum maximum* and *Setaria lindenbergiana*.

Furthermore, a second series of analyses carried out on samples of grasses cut on experimental plots at Onderstepoort, at periods of one month, two months, three months and four months. The grasses in question were five in all, namely *Chloris gayana*, *Setaria lindenbergiana*, *Cenchrus ciliaris*, *Digitaria pentzii* Pretoria Small, and *Panicum maximum*. The cutting of these grasses was really intended to obtain information on "The Influence of Frequency of Cutting on the Yield of Dry Matter" (see J. G. Louw, 1938).

These grasses, therefore, represent various growth stages up to four months for the season January to April (inclusive), 1936. Lastly, air dried samples of grasses, cut on the veld at monthly intervals and sent in from the experimental farms Armoedsvlakte, Vryburg (Bechuanaland) and Nooitgedacht, (highveld, Transvaal) were analysed. These samples were cut for analysis during the period August, 1935, to August, 1936, and analysed shortly after cutting. It is hoped to publish values for the carotene content of veldgrass samples for these areas for further periods up to date in the near future.

EXPERIMENTAL.

Samples for analyses were cut from selected experimental plots and a central position was chosen for cutting. Care was taken, that samples were not cut at the same spots where previous monthly cuttings had been made. In other words, a new position on each plot was selected for each monthly cutting. Thus the effect of cutting on the carotene content was eliminated. The fresh grass was immediately bottled in closed jars and analysed soon afterwards in the laboratory. Moisture determinations were made on the fresh grass by weighing in closed jars, before and after drying at 103° C. Fresh green grasses could be analysed without milling or any pretreatment, except that of cutting into small bits. Old, dry and mature grasses were firstly milled and sampled for analyses. All values for carotene are given in the tables, as well as moisture values where necessary, and meteorological data for the periods concerned.

METHOD AND TECHNIQUE OF ANALYSES FOR CAROTENE.

The method employed is the same as that previously adopted by the author (1935) and advocated by Guilbert (1934), except for a minor modification. After the extraction and saponification of the fat soluble pigments with alcoholic potash, the writer re-extracted the alcoholic extracts with petroleum ether instead of with ethyl-ether. This simplified the procedure considerably.

The standard for colorimetric comparison was the Dye-Standard of Guilbert, where 1 litre of the dye solution represented 2.4 mg. carotene.

DISCUSSION.

As previously indicated by the writer (1935), there is a decrease in carotene for pasture grass samples in the veld or for established grasses on plots during the dry months (winter) and this is especially marked in late winter. This fact can be clearly seen by studying Table VII and Table VIII, where values are given for veld grasses from the experimental farms at Vryburg and Ermelo. Rather dry winters were experienced during the years 1935 and 1936 as can be gathered from Table IX.

Calculating the average daily intake of carotene for cattle on the basis given by Guilbert (1937), namely 25 micrograms per Kilogram body weight and furthermore, assuming that an 800 lbs. bovine consumed on an average 15 lbs. dry weight of hay daily, we find that a deficiency of carotene existed for the dry months of June, July, August, and September, (1935 and 1936). This deficiency is based on the formula of Guilbert according to which the animal requires 9 milligram carotene per day to prevent the onset of clinical symptoms. Substantially more carotene would be necessary to build up a reserve and this the animal is able to do during the summer months. On the other hand depletion of carotene takes place very rapidly. Guilbert (1935) gives the daily withdrawals from storage as from 9 to 11 micrograms per Kilogram body weight. In comparison with 1935 and 1936 on the other hand, the years 1938 and 1939 were good years with substantial falls of rain even as late as May and July, 1939. Accordingly, the values for the season August, 1938, to August, 1939, for which reference should be made to Table I or I (a), were exceptionally high, and taken on an average there existed no deficiency for the six grasses analysed. Some of the individual grasses did show a markedly serious fall in carotene verging on the critical value to prevent clinical symptoms, in the late winter of 1938. This was largely due to a fairly dry spell from May until September when only small average rainfalls took place. Some types of grasses, as for instance *Chloris gayana* will sprout in winter even with little rain whereas *Panicum maximum* rarely does, and thus new growth is accompanied by an increase in Carotene. It is anticipated that, during the seasons when the rainfall is low and the hot weather hastens the maturing of the veld grasses, a prolonged dry spell starting with winter would result in a likely shortage of Vitamin A, if not in a serious deficiency in the summer-rainfall areas.

THE CAROTENE CONTENT OF SOUTH AFRICAN FEEDS.

TABLE I.
Carotene Content of Grasses cut monthly from Experimental Plots (Onderstepoort).
Expressed as mg. per cent. on Natural Basis.

Type of Grass.	Period.	Aug. 1938.	Sept.	Oct.	Nov.	Dec.	Jan. 1939.	Feb.	March.	April.	May.	June.	July.	Aug.
1. <i>Chloris gayana</i> ("Rhodes Grass")	Carotene	0.44	2.62	2.47	4.00	4.34	—	2.55	3.84	3.36	1.16	1.74	0.53	0.64
	Moisture	15.00	30.00	33.30	68.50	71.60	—	66.00	68.30	68.60	66.60	55.50	27.70	11.60
2. <i>Digitaria eriantha</i> var. <i>Stolonifera</i>	Carotene	0.12	1.31	4.24	5.82	10.90	—	3.95	2.80	2.77	0.79	0.48	0.33	0.27
	Moisture	8.30	23.80	32.00	63.50	72.20	—	65.40	68.70	55.50	30.00	16.60	18.10	7.70
3. <i>Cenchrus ciliaris</i> ("Buffelsgras")	Carotene	0.05	0.13	4.29	5.33	7.35	—	2.74	4.57	1.28	0.14	0.59	0.21	0.15
	Moisture	21.40	38.00	43.10	73.80	82.20	—	56.30	72.50	69.80	30.70	21.40	24.30	8.30
4. <i>Eragrostis plana</i>	Carotene	0.05	0.20	0.20	0.80	8.06	—	5.57	7.74	3.15	0.10	0.37	0.15	0.24
	Moisture	5.00	14.20	14.00	30.50	45.10	—	41.80	70.30	54.50	20.00	20.00	17.00	13.80
5. <i>Panicum maximum</i> (Hairy "Buffelsgras")	Carotene	0.09	0.21	1.13	2.00	7.70	—	1.73	2.62	2.77	0.18	0.14	0.04	0.06
	Moisture	14.80	26.00	12.30	48.80	75.00	—	71.10	72.50	54.70	31.70	30.00	25.00	7.40
6. <i>Setaria lindenbergiana</i>	Carotene	0.47	0.40	1.93	2.91	9.41	—	4.57	3.60	3.20	0.34	0.33	0.16	0.24
	Moisture	15.20	31.10	9.50	16.00	72.10	—	60.20	60.00	50.00	34.50	18.10	26.50	6.10

TABLE I (a).
*Carotene Content of Grasses cut monthly from Experimental Plots (Onderstepoort).
 Expressed as mg. percentage on dry basis.*

Type of Grass.	Period.	Aug. 1938.	Sept.	Oct.	Nov.	Dec.	Jan. 1939.	Feb.	March.	April.	May.	June.	July.	Aug.
1. <i>Chloris gayana</i> ("Rhodes Grass")	—	0.52	3.75	3.70	12.70	15.30	—	7.50	12.10	10.70	3.47	3.91	0.73	0.71
2. <i>Digitaria eriantha</i> var. <i>Stolonifera</i>	—	0.13	1.72	6.23	16.00	39.20	—	11.40	8.94	6.23	1.13	0.58	0.40	0.29
3. <i>Cenchrus ciliaris</i> ("Buffelsgras")	—	0.06	0.21	7.54	20.30	41.30	—	6.26	16.60	4.23	0.20	0.75	0.28	0.16
4. <i>Eragrostis plana</i>	—	0.05	0.23	0.23	1.15	14.70	—	9.56	26.10	6.92	0.12	0.46	0.18	0.28
5. <i>Panicum maximum</i> (Hairy "Buffelsgras")	—	0.11	0.28	1.29	3.91	30.85	—	5.98	9.52	6.10	0.23	0.20	0.05	0.06
6. <i>Setaria lindenbergiana</i>	—	0.55	0.58	2.13	3.46	33.70	—	11.50	9.00	6.40	0.52	0.40	0.22	0.25

TABLE II.
Daily Intake of Carotene (mg.) for Cattle (800 lb. Live-weight) calculated from Table I (a).

Type of Grass.	Aug. 1938.	Sept.	Oct.	Nov.	Dec.	Jan. 1939.	Feb.	March.	April.	May.	June.	July.	Aug.
1. <i>Chloris gayana</i> ("Rhodes Grass").....	35	253	250	857	1,032	—	506	818	723	234	264	49	49
2. <i>Digitaria eriantha</i> var. <i>Stolonifera</i>	9	116	420	1,080	2,664	—	769	603	420	76	39	27	20
3. <i>Cenchrus ciliaris</i> ("Buffelsgras").....	4	14	508	1,370	2,790	—	423	1,120	285	14	51	19	11
4. <i>Eragrostis plana</i>	3	16	15	78	990	—	645	1,760	467	8	31	12	19
5. <i>Panicum maximum</i> (Hairy "Buffelsgras").....	7	19	87	264	2,080	—	403	642	414	15	13	4	4
6. <i>Setaria lindenbergiana</i>	37	39	144	233	2,275	—	775	607	433	35	27	15	17
Average for 6 Grasses.....	16	76	237	647	1,972	—	587	925	457	64	71	21	20
Minimum Daily Requirement according to Guilbert...	9	9	9	9	9	9	9	9	9	9	9	9	9

THE CAROTENE CONTENT OF SOUTH AFRICAN FEEDS.

TABLE III.

Meteorological Data—Onderstepoort, Transvaal.

Date.	Average Rainfall.	Average Maximum Temperature.	Average Minimum Temperature.	Difference between Maximum and Minimum Temperature.
1938.				
	(Inches).	°F.	°F.	°F.
January.....	5.52	82.2	59.7	22.5
February.....	2.56	79.4	58.8	20.6
March.....	1.24	86.9	52.2	34.7
April.....	2.94	83.8	48.0	35.8
May.....	0.30	77.0	38.6	38.4
June.....	0.19	68.1	35.6	32.5
July.....	0	60.5	34.3	26.2
August.....	0.24	66.6	36.6	30.0
September.....	0.33	74.9	39.8	35.1
October.....	2.81	82.5	55.4	27.1
November.....	1.23	86.7	52.6	34.1
December.....	10.70	84.4	54.5	29.9
1939.				
January.....	5.24	84.8	57.4	27.4
February.....	8.82	84.0	58.2	25.8
March.....	2.75	75.7	48.6	27.1
April.....	0.07	74.2	44.2	30.0
May.....	2.54	74.0	39.9	34.1
June.....	0	68.5	32.8	35.7
July.....	2.44	65.4	33.8	31.6
August.....	0.40	70.2	37.5	32.7

TABLE IV.

Carotene Content of Plot Grasses cut from Experimental Plots, Onderstepoort, expressed as mg. Per cent Carotene on Dry Basis.

Date of Analysis. 1937.	<i>Chloris gayana.</i>	<i>Setaria linden- bergiana.</i>	<i>Cenchrus ciliaris.</i>	<i>Digitaria pentzii Pretoria Small.</i>	<i>Panicum maximum.</i>
1-Monthly Cuttings 6/1/36 ; 4/2/36 ; 3/3/36 ; 5/4/36 (pooled).	2.36	3.00	2.40	1.86	2.12
2-Monthly Cuttings 4/2/36 ; 6/4/36 (pooled)	2.00	1.71	1.80	1.50	1.89
3-Monthly Cuttings 3/3/36...	0.90	1.74	1.74	1.20	1.71
4-Monthly Cuttings 6/4/36...	0.85	1.62	1.33	1.30	1.20

TABLE V.

Daily Intake of Carotene (mg.) for Cattle (800 lb. Live-weight) calculated from Table IV.

	<i>Chloris gayana.</i>	<i>Setaria linden- bergiana.</i>	<i>Cenchrus ciliaris</i>	<i>Digitaria pentzii Pretoria Small.</i>	<i>Panicum maximum.</i>
1-Monthly Cuttings.....	159	202	162	126	143
2-Monthly Cuttings.....	135	115	121	101	128
3-Monthly Cuttings.....	61	117	117	81	115
4-Monthly Cuttings.....	57	109	90	87	81
Average Minimum Requirement	9	9	9	9	9

TABLE VI.

Meteorological Data—Onderstepoort.

Date.	Average Rainfall.	Average Maximum Temperature.	Average Minimum Temperature.	Difference between Maximum and Minimum Temperature.
1935.				
	(Inches).	F.	F.	F.
September.....	0.36	81.8	43.9	37.9
October.....	0.97	91.1	52.2	38.9
November.....	2.09	88.2	55.5	32.7
December.....	3.17	87.6	56.8	30.8
1936.				
January.....	4.69	87.6	58.1	29.5
February.....	7.67	85.2	58.3	26.9
March.....	8.50	80.0	56.1	23.9
April.....	0.51	79.8	49.0	30.8
May.....	4.26	71.4	40.6	30.8
June.....	0	72.1	33.4	38.7
July.....	0	70.7	33.6	37.1
August.....	0	76.0	36.2	39.8
September.....	0.46	77.6	40.6	37.0
October.....	2.69	83.2	51.4	31.8
November.....	0.54	82.2	54.5	27.7
December.....	3.37	88.0	55.5	32.5

TABLE VII.
A.—Carotene Content of Veld Grass—Armoedsvlakte, Vryburg, expressed as mg. per cent.
Carotene on Dry Basis.

	Aug. 1935.	Sept.	Oct.	Nov.	Dec.	Jan. 1936.	Feb.	March.	April.	May.	June.	July.	Aug.
	·06	·10	·28	·28	·55	1·08	0·71	0·83	1·15	0·70	0·08	0·11	0·12

B.—Daily Intake of Carotene (mg.) for Cattle (800 lb. Live-weight) calculated from Table VII.

	Aug. 1935.	Sept.	Oct.	Nov.	Dec.	Jan. 1936.	Feb.	March.	April.	May.	June.	July.	Aug.
	4	7	19	19	37	73	48	56	77	77	5	7	8
Average minimum requirement.....	9	9	9	9	9	9	9	9	9	9	9	9	9

TABLE VIII.
A.—Carotene Content of Veld Grass—Experimental Farm, Ermelo, expressed as mg. per cent.
Carotene on Dry Basis.

	Aug. 1935.	Sept.	Oct.	Nov.	Dec.	Jan. 1936.	Feb.	March.	April.	May.	June.	July.	Aug.
	0·18	0·08	0·13	0·36	1·34	1·00	1·07	1·50	1·07	0·60	0·13	0·05	0·08

B.—Daily Intake of Carotene (mg.) for Cattle (800 lb. Live-weight) calculated from Table VIII.

	Aug. 1935.	Sept.	Oct.	Nov.	Dec.	Jan. 1936.	Feb.	March.	April.	May.	June.	July.	Aug.
	12	5	9	24	90	67	72	101	72	40	9	3	5
Average Minimum Requirements.....	9	9	9	9	9	9	9	9	9	9	9	9	9

TABLE IX.

Meteorological Data—Armoedsvlakte, Vryburg, Bechuanaland.

Date.	Average. Rainfall.	Average Maximum Temperature.	Average Minimum Temperature.	Difference between Maximum and Minimum Temperature.
1935.				
	(Inches).	F.	F.	F.
January.....	0.93	92.74	56.15	36.59
February.....	2.69	86.84	56.99	29.85
March.....	2.66	80.47	53.54	26.93
April.....	1.94	75.49	46.51	28.98
May.....	0.60	69.31	37.37	31.94
June.....	0	64.93	29.20	35.73
July.....	0	70.20	31.20	39.00
August.....	0	68.76	31.09	37.67
September.....	0.25	77.82	39.98	37.84
October.....	0.52	90.48	53.76	36.72
November.....	1.15	86.76	54.98	31.78
December.....	3.98	88.43	59.89	28.54
1936.				
January.....	2.51	87.74	57.36	30.28
February.....	3.61	85.94	58.02	29.96
March.....	3.23	78.98	56.08	22.90
April.....	0.06	79.96	46.61	33.35
May.....	1.11	68.27	39.82	28.45
June.....	0.02	69.13	32.65	26.48
July.....	0	67.84	33.15	34.72
August.....	0	74.50	34.70	39.80

SUMMARY.

1. Carotene values are given for six well-known grasses, cut monthly from established plots under natural climatic conditions at Onderstepoort from August, 1938, to August, 1939.

2. If the average bovine (800 lb. body weight) requires 9 milligrams carotene per day, then there exists no actual Vitamin-A deficiency for the season in question.

3. Carotene values are given for grasses cut at one-monthly up to four-monthly periods during the growth stage.

4. The average intakes of carotene from these grasses are well above the minimum requirements of stock.

5. Carotene values are given for veld grasses cut on the veld from the areas Vryburg, Bechuanaland and Ermelo on the Highveld of the Transvaal during the years 1935 and 1936, and analysed shortly afterwards.

6. Here for the period in question, there is a strong indication of a likely Vitamin A deficiency during the dry months.

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ERRORS IN PUBLICATION, 1935.

(a) 50 c.c. of the stock solution to 1,000 c.c. etc., should read 5.0 c.c. of the stock solution to 1,000 c.c., etc. See page 479.

(b) Value of Dye Standard used = 2.7 per 1,000 c.c. carotene and not per cent., as given in Tables A and B. See page 479.

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