THE QUEENSLAND JOURNAL OF AGRICULTURAL SCIENCE

MARCH, 1959.

VOL. 16. NO. 1.

VARIATIONS IN THE CAROTENE AND VITAMIN A CONTENTS OF QUEENSLAND BUTTERFATS

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SUMMARY.

Data from a survey of the carotene and vitamin A contents of Queensland butterfats are presented.

Butter samples were submitted at fortnightly intervals in 1954 and 1955 from 12 dairying centres, predominantly in south-eastern Queensland. Each sample was representative of cream supplies received at the particular butter factory at the time of sampling.

The mean annual carotene, vitamin A and total vitamin A contents of Queensland butterfats were 12.8, 38.6 and 51.4 I.U./g. respectively. The mean proportion of total vitamin A potency due to carotene was 24.9 per cent.

Marked seasonal trends in the carotene, vitamin A and total vitamin A contents of butterfats were found in both years. Maximum values occurred between midwinter and early spring. Minimum values occurred between midsummer and early autumn.

There were no marked differences in the carotene and vitamin A contents of butterfats from the 12 centres. There were no marked differences between levels recorded in 1954 and 1955.

The average total vitamin A potency of Queensland butter in both summer and winter was higher than values published for other countries.

An examination of the influence of breed of dairy cattle showed that Australian Illawarra Shorthorn cows secrete less carotene and less carotenol pigments in butterfat than Jersey cows.

The marked seasonal variations in the total vitamin A potency of butterfat may be related to the stage of lactation and to other factors which affect production in the dairy cow. Variations do not appear to be a function of the level of carotene in the pasture ingested by the grazing animal.

I. INTRODUCTION.

The first extensive survey of the seasonal variation in the vitamin A potency of milk and butter produced and marketed in different regions was made in the United States of America (Cary 1947). In all but two of the 16 States examined there was a definite difference between the vitamin A potency of butter produced in winter and that of butter produced in summer. Winter butter had, on the average, two-thirds the vitamin A potency of summer butter.

In a survey of the vitamin A potency of New Zealand butter over three years, McDowell and McDowall (1953) found uniform and regularly recurring seasonal variations in both the carotene and vitamin A contents of the butterfats. Maximum values were found in late autumn, winter and early spring, with minimum values in late summer and early autumn. Summer butter had, on the average, four-fifths the vitamin A potency of winter butter.

The only previous investigation of the carotene and vitamin A content of Australian butterfat was conducted in Victoria by Farrer, Balding, Warren and Miller (1949). Analysing a limited number of samples taken at uneven intervals throughout the year, they found maximum values for total vitamin A potency in late winter or early spring; minimum values were found in late summer or early autumn.

This paper presents the results of a survey of the carotene and vitamin A contents of butter samples submitted from 12 dairying centres in Queensland. Except for unforeseen circumstances, samples were submitted at fortnightly intervals for two years.

The vitamin A potencies of the butters from individual centres and the five districts they represent are compared. Data on breeds, production, stage of lactation and rainfall were collected to determine whether the values found could be related to any of these factors.

II. METHODS.

(1) Sampling of Butters.

Twelve dairying centres were selected from which samples were submitted for analysis. These samples were also examined by Mitchell (1959) for softening point and iodine value. As shown in Fig. 1, the centres are predominantly in south-eastern Queensland, where the greatest concentration of dairy cattle occurs. Each centre contained one butter factory.

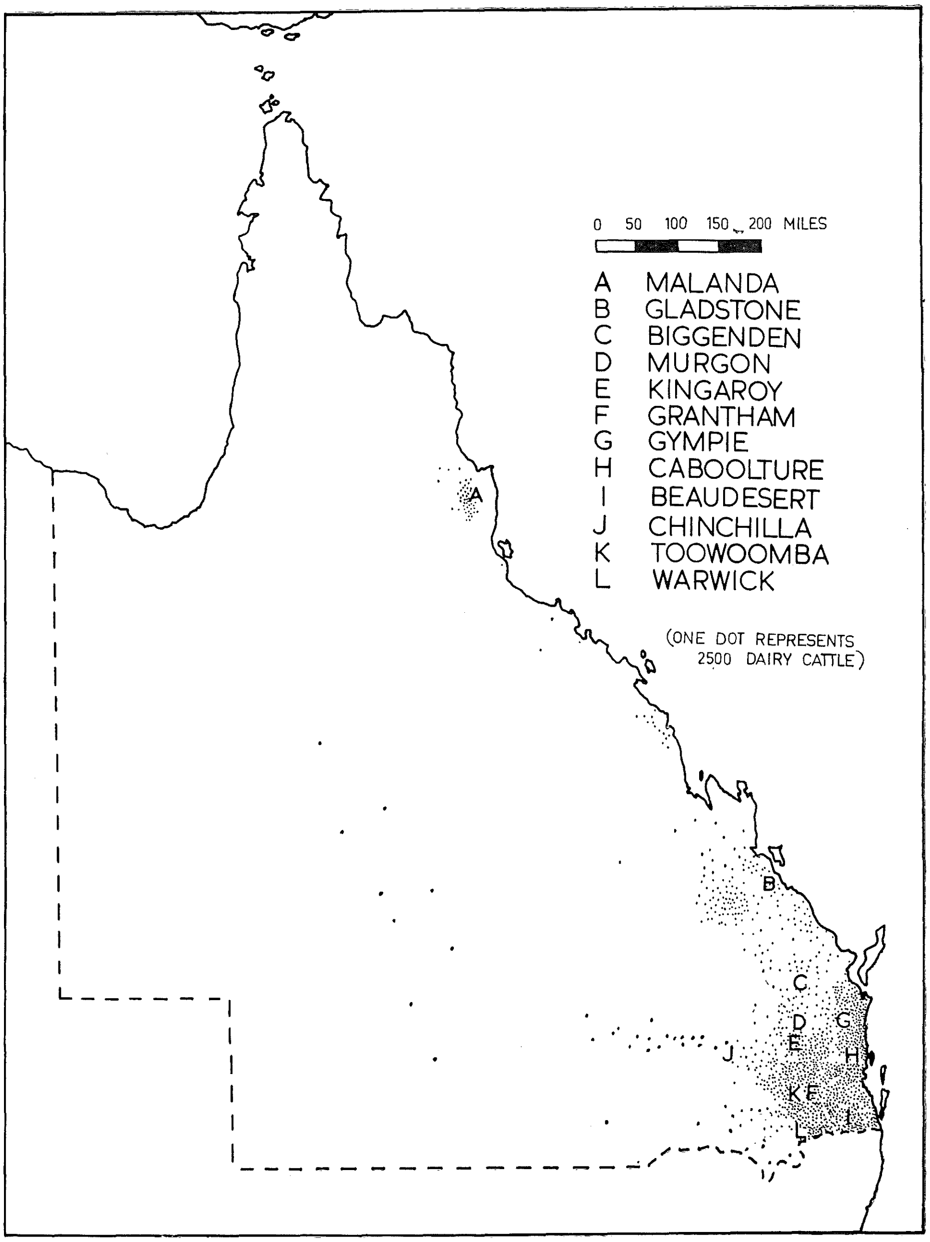

Fig. 1.

Map Showing Distribution of Dairy Cattle in Queensland and the Centres from Which Butter Samples Were Submitted.

The centres were grouped into districts as follows:—

District.	*Centre.*
Atherton Tableland ..	Malanda
Port Curtis	Gladstone
Burnett—West Moreton ..	Biggenden, Murgon, Kingaroy, Grantham
Wide Bay—East Moreton ..	Gympie, Caboolture, Beaudesert
Darling Downs	Chinchilla, Toowoomba, Warwick

Samples were collected at fortnightly intervals from all factories. Each sample was a 1 lb. portion from a single churning. This sample was double-wrapped in parchment and forwarded to Brisbane in an insulated railway waggon. The samples were refrigerated on arrival at the laboratory and stored at approximately 4 deg. C. until analysed. At certain periods abnormal seasonal conditions disrupted regular sampling. Several consignments from the Malanda factory deteriorated during transit because of excessive delay.

Samples were representative of cream supplies received at the factories concerned at the time of sampling. All butter was of choice grade except during the months of low production, when several factories churned a blend of choice and first grades.

With each sample the following data were supplied by field officers:—

(*a*) Breed distribution.

(*b*) Weekly factory production.

(*c*) Stage of lactation of herds.

(*d*) Rainfall for fortnight.

(2) Chemical Analysis.

Two samples were received in most months, but in some months either one or three samples were received. Throughout 1954 each sample received was analysed and monthly averages were calculated. In 1955, all samples submitted from a centre in the one month were bulked by taking equal weights (50 g.) and composite samples were analysed.

All analyses were done on butterfat. Butter samples were taken from the centre of a pat. They were melted over a boiling water bath, then centrifuged, and the fat was decanted into containers. These were stored at approximately 4 deg. C. until analysed.

The analytical saponification and extraction procedure was essentially that of McDowell (1949). Due to its greater stability with potassium hydroxide, methanol was used in the saponification rather than ethanol. Vitamin A was estimated on duplicate 10 ml. aliquots of the ether extract (equivalent to $0 \cdot 8$ g. butterfat) by means of the Carr Price reaction. The photo-electric recording technique was that described by Gartner and Ryley (1956).

Recovery studies showed an average loss of $7 \cdot 5$ per cent. of vitamin A added to butterfat. Similar losses were recorded by American workers (Cary 1947). In the data presented below, corrections have been made on the basis of a $7 \cdot 5$ per cent. loss in vitamin A.

Total carotenoid was estimated on duplicate 10 ml. portions of the ether extract. Each aliquot was placed in a photometer test tube (2 cm. light path) and by means of a hot plate was evaporated to dryness under a stream of carbon dioxide. The pigments were taken up in 15 ml. petroleum ether (Shell X 222). The transmittance was measured at 440 mμ, using a Lumetron photo-electric colorimeter. The reference standard was 90 per cent. beta-carotene 10 per cent. alpha-carotene distributed by Eastman Kodak Company, Rochester, N.Y.

The method of Berl and Paterson (1943) was used to determine carotene. Xanthophylls were removed by partition of the petroleum ether extract previously used in the estimation of carotenoids. The solvent was 94 per cent. diacetone alcohol saturated with petroleum ether. This caused no change in volume of the petroleum ether extract. Transmittance was measured as for carotenoids.

In calculating the vitamin A content of the butterfats, corrections were made for the amount of blue colour contributed by carotene in the Carr Price reaction.

Carotene levels determined in micrograms were converted to vitamin A equivalent on the basis of $0 \cdot 6$ μg. carotene equivalent to 1 I.U. vitamin A. Total vitamin A potency of butterfats then became the sum potencies for carotene and vitamin A expressed as I.U. of vitamin A.

III. RESULTS.

(1) General.

Within any one month the carotene and vitamin A contents of butterfats from a centre varied appreciably. The average variation in the carotene content was $1 \cdot 1$ I.U. and the range 0–$4 \cdot 4$ I.U. The average variation in the vitamin A content was $3 \cdot 5$ I.U. and the range 0–$11 \cdot 4$ I.U. Only monthly averages are considered in presenting the results for 1954. For 1955, the results are representative of composite samples submitted in any one month.

The monthly averages for carotene, vitamin A and total vitamin A potency of butterfats are presented in Tables 1, 2 and 3 respectively. District and all centre averages are given in addition to average values for individual centres. The predominant breed of dairy cattle is shown for each centre and averages for centres with either predominantly Jersey, Australian Illawarra Shorthorn (A.I.S.) or mixed breeds are given.

Table 1.

MONTHLY CAROTENE CONCENTRATION OF BUTTERFATS FROM EACH CENTRE AND AVERAGES FOR DISTRICTS AND BREEDS (I.U./g).

Districts—Centres—Breeds.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
					1954.								
Atherton Tableland—													
***Malanda	8·7	12·8	11·1	10·2	10·5	10·6	11·6	11·1	11·3	11·0	10·2	10·0	10·8
Port Curtis—													
*Gladstone	12·8	18·0	14·2	10·5	10·5	10·4	10·9	13·7	16·2	14·4	13·3	13·2	13·2
Burnett–West Moreton—													
**Biggenden	11·1	13·5	14·0	10·6	10·1	†	†	14·8	12·8	15·5	14·2	12·8	
**Murgon	11·6	13·9	12·9	10·8	11·6	12·4	11·3	14·1	16·9	17·3	15·2	10·2	13·2
**Kingaroy	12·1	13·0	12·5	10·5	10·8	†	15·3	13·2	15·9	13·9	12·7	12·2	
**Grantham	13·1	14·8	12·9	9·0	8·9	9·9	10·3	13·9	15·3	14·1	14·0	11·3	12·3
District Average	12·0	13·8	13·1	10·2	10·4	11·2	12·3	14·0	15·2	15·2	14·0	11·6	12·8
Wide Bay–East Moreton—													
*Gympie	13·3	14·5	13·7	10·8	12·3	12·5	12·3	13·2	15·7	16·9	15·6	12·9	13·6
*Caboolture	12·5	16·1	14·0	11·8	12·1	12·2	11·8	13·4	15·4	15·5	14·6	11·8	13·4
**Beaudesert	11·7	15·0	14·4	10·8	10·1	10·5	12·2	13·9	15·0	14·8	15·0	10·9	12·9
District Average	12·5	15·2	14·0	11·1	11·5	11·7	12·1	13·5	15·4	15·7	15·1	11·9	13·3
Darling Downs—													
***Chinchilla	11·7	12·0	13·8	11·8	10·9	10·0	11·2	14·0	14·6	12·7	12·8	11·9	12·3
**Toowoomba	11·4	14·7	13·7	11·9	12·7	11·4	12·1	14·3	16·2	15·3	13·7	12·1	13·3
***Warwick	7·6	11·1	13·3	9·2	9·5	9·7	10·7	13·3	15·5	12·7	11·3	11·1	11·3
District Average	10·2	12·6	13·6	11·0	11·0	10·4	11·3	13·9	15·4	13·6	12·6	11·7	12·3
All Centres Average	11·5	14·1	13·4	10·7	10·8	11·0	11·8	13·6	15·1	14·5	13·6	11·7	12·7
*Predominantly Jersey Centres ..	12·9	16·2	14·0	11·0	11·6	11·7	11·7	13·4	15·8	15·6	14·5	12·6	13·4
**Mixed Breed Centres	11·8	14·2	13·4	10·6	10·7	11·1	12·2	14·0	15·4	15·2	14·1	11·6	12·9
***Predominantly A.I.S. Centres ..	9·3	12·0	12·7	10·4	10·3	10·1	11·2	12·8	13·8	12·1	11·4	11·0	11·4

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1955.

Atherton Tableland—													
***Malanda	9·8	10·0	12·7	10·8	11·2	11·0	10·2	11·3	†	†	†	†	
Port Curtis—													
*Gladstone	12·6	14·9	14·2	12·6	12·2	12·8	14·6	12·8	13·4	14·2	15·0	12·3	13·5
Burnett–West Moreton—													
**Biggenden	10·3	11·0	16·0	13·2	11·5	11·0	12·7	13·9	14·5	15·7	13·7	13·9	13·1
**Murgon	10·0	9·3	13·6	14·2	13·2	14·6	14·9	15·7	17·9	15·4	14·7	11·9	13·8
**Kingaroy	10·2	10·2	12·8	13·4	12·8	13·4	13·9	14·9	14·6	14·8	13·3	11·2	13·0
**Grantham	9·9	12·1	12·0	11·8	11·6	12·5	13·8	15·1	13·8	14·5	13·1	11·6	12·7
District Average	10·1	10·7	13·6	13·2	12·3	12·9	13·8	14·9	15·2	15·1	13·7	12·2	13·1
Wide Bay–East Moreton—													
*Gympie	10·6	14·1	14·3	13·2	12·8	12·3	13·8	14·6	13·8	16·1	15·4	13·4	13·7
*Caboolture	11·1	11·5	11·8	12·6	12·1	13·3	13·4	12·7	14·8	14·9	14·9	12·7	13·0
**Beaudesert	9·9	10·6	12·0	12·3	11·9	12·5	13·8	13·3	13·5	13·8	14·2	12·1	12·5
District Average	10·5	12·1	12·7	12·7	12·3	12·7	13·7	13·5	14·0	14·9	14·8	12·7	13·1
Darling Downs—													
***Chinchilla	10·2	10·1	11·5	10·9	11·1	14·8	14·5	15·5	16·2	12·0	†	11·5	
**Toowoomba	9·5	11·7	12·7	13·8	12·9	14·6	16·0	16·3	15·3	15·5	12·5	11·2	13·5
***Warwick	9·3	9·5	8·9	11·1	†	15·0	13·9	15·0	†	†	10·2	10·0	
District Average	9·7	10·4	11·0	11·9	12·0	14·8	14·8	15·6	15·8	13·8	11·4	10·9	12·7
All Centres Average	10·3	11·3	12·7	12·5	12·1	13·2	13·8	14·3	14·8	14·7	13·7	12·0	13·0
*Predominantly Jersey Centres ..	11·4	13·5	13·4	12·8	12·4	12·8	13·9	13·4	14·0	15·1	15·1	12·8	13·4
**Mixed Breed Centres	10·0	10·8	13·2	13·1	12·3	13·1	14·2	14·9	14·9	15·0	13·6	12·0	13·1
***Predominantly A.I.S. Centres ..	9·8	9·9	11·0	10·9	11·2	13·6	12·9	13·9	16·2	12·0	10·2	10·8	11·9
All Centres Average 1954–55 ..	10·9	12·7	13·1	11·6	11·5	12·1	12·8	14·0	15·0	14·6	13·7	11·9	12·8

† Samples unavailable.

Table 2.

MONTHLY VITAMIN A CONCENTRATION OF BUTTERFATS FROM EACH CENTRE AND AVERAGES FOR DISTRICTS AND BREEDS (I.U./g).

Districts—Centres—Breeds.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
						1954.							
Atherton Tableland—													
***Malanda	33·6	33·0	30·1	32·3	36·2	40·0	39·8	41·2	38·3	38·3	35·1	28·4	35·5
Port Curtis—													
*Gladstone	23·0	28·7	28·0	32·7	35·0	42·5	46·3	48·2	46·1	41·2	37·7	37·8	37·3
Burnett–West Moreton—													
**Biggenden	31·7	27·5	29·2	32·6	41·5	†	†	44·5	46·9	34·3	37·2	34·2	
**Murgon	31·2	31·2	29·3	35·9	41·3	40·8	49·0	46·3	44·9	39·9	34·0	28·0	37·7
**Kingaroy	35·0	30·5	31·5	34·9	39·1	†	52·6	47·2	40·4	40·3	35·5	33·5	
**Grantham	32·8	33·0	31·3	33·0	37·2	42·5	51·0	45·1	43·2	35·0	35·3	33·2	37·7
District Average	32·7	30·6	30·3	34·1	39·8	41·7	50·9	45·8	43·9	37·4	35·5	32·2	37·9
Wide Bay–East Moreton—													
*Gympie	28·0	30·1	29·6	32·9	39·1	42·9	48·1	48·7	46·8	43·1	32·3	30·8	37·7
*Caboolture	27·5	29·7	28·4	31·4	33·5	37·9	45·8	45·2	44·9	36·9	36·7	30·7	35·7
**Beaudesert	38·7	36·7	29·9	31·9	39·3	45·9	50·5	50·1	44·0	39·5	35·0	31·1	39·4
District Average	31·4	32·2	29·3	32·1	37·3	42·2	48·1	48·0	45·2	39·8	34·7	30·9	37·6
Darling Downs—													
***Chinchilla	29·9	38·4	28·2	35·0	40·3	38·6	44·7	48·4	42·8	38·3	36·9	33·0	37·9
**Toowoomba	37·8	32·1	33·6	29·9	38·0	37·5	43·5	45·0	41·1	35·2	35·3	31·2	36·7
***Warwick	37·4	42·6	32·3	35·1	32·9	41·3	47·7	50·0	45·1	38·9	36·5	36·0	39·7
District Average	35·0	37·7	31·4	33·3	37·1	39·1	45·3	47·8	43·0	37·5	36·2	33·4	38·1
All Centres Average	32·2	32·8	30·1	33·1	37·8	41·0	47·2	46·7	43·7	38·4	35·6	32·3	37·6
*Predominantly Jersey Centres ..	26·2	29·5	28·7	32·3	35·9	41·1	46·7	47·4	45·9	40·4	35·6	33·1	36·9
**Mixed Breed Centres	34·5	31·8	30·8	33·0	39·4	41·7	49·3	46·4	43·4	37·4	35·4	31·9	37·9
***Predominantly A.I.S. Centres ..	33·6	38·0	30·2	34·1	36·5	40·0	44·1	46·5	42·1	38·5	36·2	32·5	37·7

1955.

Atherton Tableland—													
***Malanda	36·1	37·3	35·4	32·3	36·3	36·3	40·8	37·6	†	†	†	†	
Port Curtis—													
*Gladstone	34·5	29·0	29·1	32·8	35·6	39·0	44·3	41·8	49·4	46·9	42·0	39·6	38·7
Burnett–West Moreton—													
**Biggenden	29·3	31·5	29·6	33·1	36·8	42·6	47·0	49·1	49·0	50·2	40·1	33·0	39·3
**Murgon	30·1	34·0	31·3	36·1	41·8	45·4	51·0	43·8	48·4	41·6	35·1	39·2	39·8
**Kingaroy	30·8	36·3	33·9	39·0	44·2	48·0	50·7	45·4	42·4	36·7	37·9	39·2	40·4
**Grantham	31·8	31·4	27·4	36·5	36·6	43·9	48·7	51·9	44·7	46·5	36·4	37·0	39·4
District Average	30·5	33·3	30·6	36·2	39·9	45·0	49·4	47·6	46·1	43·8	37·4	37·1	39·7
Wide Bay–East Moreton—													
*Gympie	29·4	30·4	27·0	30·9	33·3	44·5	49·9	55·6	52·0	47·3	41·6	33·1	39·6
*Caboolture	32·7	31·1	29·3	33·9	36·4	36·4	45·2	46·8	49·3	46·1	37·3	34·8	38·3
**Beaudesert	31·1	31·5	30·7	35·8	39·7	46·2	53·1	53·5	47·8	42·9	37·4	33·3	40·3
District Average	31·1	31·0	29·0	33·5	36·5	42·4	49·4	52·0	49·7	45·4	38·8	33·7	39·4
Darling Downs—													
***Chinchilla	35·6	37·7	34·0	41·5	47·2	47·6	55·7	53·7	47·6	32·7	†	35·3	
**Toowoomba	33·1	27·8	31·1	36·6	40·2	44·1	52·2	47·0	38·5	36·4	33·0	33·0	37·8
***Warwick	32·6	30·4	31·4	41·6	†	45·6	54·5	51·1	†	†	40·3	40·8	
District Average	33·8	32·0	32·2	39·9	43·7	45·8	54·1	50·6	43·1	34·6	36·7	36·4	40·2
All Centres Average	32·3	32·4	30·9	35·8	38·9	43·3	49·4	48·1	46·9	42·7	38·1	36·2	39·6
*Predominantly Jersey Centres ..	32·2	30·2	28·5	32·5	35·1	40·0	46·5	48·1	50·2	46·8	40·3	35·8	38·9
**Mixed Breed Centres	31·0	32·1	30·7	36·2	39·9	45·0	50·5	48·5	45·1	42·4	36·7	35·8	39·5
***Predominantly A.I.S. Centres ..	34·8	35·1	33·6	38·5	41·8	43·2	50·3	47·5	47·6	32·7	40·3	38·1	40·3
All Centres Average 1954–1955 ..	32·3	32·6	30·5	34·5	38·4	42·2	48·3	47·4	45·3	40·6	36·9	34·3	38·6

† Samples unavailable.

Table 3.

MONTHLY TOTAL VITAMIN A POTENCY OF BUTTERFATS FROM EACH CENTRE AND AVERAGES FOR DISTRICTS AND BREEDS (I.U./g).

Districts—Centres—Breeds.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
					1954.								
Atherton Tableland—													
***Malanda	42·3	45·8	41·2	42·5	46·7	50·6	51·4	52·3	49·6	49·3	45·3	38·4	46·3
Port Curtis—													
*Gladstone	35·8	46·7	42·2	43·2	45·5	52·9	57·2	61·9	62·3	55·6	51·0	51·0	50·5
Burnett–West Moreton—													
**Biggenden	42·8	41·0	43·2	43·2	51·6	†	†	59·3	59·7	49·8	51·4	47·0	
**Murgon	42·8	45·1	42·2	46·7	52·9	53·2	60·3	60·4	61·8	57·2	49·2	38·2	50·9
**Kingaroy	47·1	43·5	44·0	45·4	49·9	†	67·9	60·4	56·3	54·2	48·2	45·7	
**Grantham	45·9	47·8	44·2	42·0	46·1	52·4	61·3	59·0	58·5	49·1	49·3	44·5	50·0
District Average	44·7	44·4	43·4	44·3	50·2	52·9	63·2	59·8	59·1	52·6	49·5	43·8	50·7
Wide Bay–East Moreton—													
*Gympie	41·3	44·6	43·3	43·7	51·4	55·4	60·4	61·9	62·5	60·0	47·9	43·7	51·3
*Caboolture	40·0	45·8	42·4	43·2	45·6	50·1	57·6	58·6	60·3	52·4	51·3	42·5	49·1
**Beaudesert	50·4	51·7	44·3	42·7	49·4	56·4	62·7	64·0	59·0	54·3	50·0	42·0	52·3
District Average	43·9	47·4	43·3	43·2	48·8	53·9	60·2	61·5	60·6	55·5	49·8	42·8	50·9
Darling Downs—													
***Chinchilla	41·6	50·4	42·0	46·8	51·2	48·6	55·9	62·4	57·4	51·0	49·7	44·9	50·2
**Toowoomba	49·2	46·8	47·3	41·8	50·7	48·9	55·6	59·3	57·3	50·5	49·0	43·3	50·0
***Warwick	45·0	53·7	45·6	44·3	42·4	51·0	58·4	63·3	60·6	51·6	47·8	47·1	51·0
District Average	45·2	50·3	45·0	44·3	48·1	49·5	56·6	61·7	58·4	51·1	48·8	45·1	50·4
All Centres Average	43·7	46·9	43·5	43·8	48·6	52·0	59·0	60·3	58·8	52·9	49·2	44·0	50·3
*Predominantly Jersey Centres ..	39·1	45·7	42·7	43·3	47·5	52·8	58·4	60·8	61·7	56·0	50·1	45·7	50·3
**Mixed Breed Centres	46·3	46·0	44·2	43·6	50·1	52·8	61·5	60·4	58·8	52·6	49·5	43·5	50·8
***Predominantly A.I.S. Centres ..	42·9	50·0	42·9	44·5	46·8	50·1	55·3	59·3	55·9	50·6	47·6	43·5	49·1

1955.

Atherton Tableland—													
***Malanda	45·9	47·3	48·1	43·1	47·5	47·3	51·0	48·9	†	†	†	†	
Port Curtis—													
*Gladstone	47·1	43·9	43·3	45·4	47·8	51·8	58·9	54·6	62·8	61·1	57·0	51·9	52·2
Burnett–West Moreton—													
**Biggenden	39·6	42·5	45·6	46·3	48·3	53·6	59·7	63·0	63·5	65·9	53·8	46·9	52·4
**Murgon	40·1	43·3	44·9	50·3	55·0	60·0	65·9	59·5	66·3	57·0	49·8	51·1	53·6
**Kingaroy	41·0	46·5	46·7	52·4	57·0	61·4	64·6	60·3	57·0	51·5	51·2	50·4	53·4
**Grantham	41·7	43·5	39·4	48·3	48·2	56·4	62·5	67·0	58·5	61·0	49·5	48·6	52·1
District Average	40·6	44·0	44·2	49·4	52·2	57·9	63·2	62·5	61·3	58·9	51·1	49·3	52·8
Wide Bay–East Moreton—													
*Gympie	40·0	44·5	41·3	44·1	46·1	56·8	63·7	70·2	65·8	63·4	57·0	46·5	53·3
*Caboolture	43·8	42·6	41·1	46·5	48·5	49·7	58·6	59·5	64·1	61·0	52·2	47·5	51·3
**Beaudesert	41·0	42·1	42·7	48·1	51·6	58·7	66·9	66·8	61·3	56·7	51·6	45·4	52·8
District Average	41·6	43·1	41·7	46·2	48·8	55·1	63·1	65·5	63·7	60·3	53·6	46·4	52·5
Darling Downs—													
***Chinchilla	45·8	47·8	45·5	52·4	58·3	62·4	70·2	69·2	63·8	44·7	†	46·8	
**Toowoomba	42·6	39·5	43·8	50·4	53·1	58·7	68·2	63·3	53·8	51·9	45·5	44·2	51·3
***Warwick	41·9	39·9	40·3	52·7	†	60·6	68·4	66·1	†	†	50·5	50·8	
District Average	43·5	42·4	43·2	51·8	55·7	60·6	68·9	66·2	58·9	48·4	48·1	47·3	52·9
All Centres Average	42·6	43·7	43·6	48·3	51·0	56·5	63·2	62·4	61·7	57·4	51·8	48·2	52·6
*Predominantly Jersey Centres ..	43·6	43·7	41·9	45·3	47·5	52·8	60·4	61·5	64·2	61·9	55·4	48·6	52·3
**Mixed Breed Centres	41·0	42·9	43·9	49·3	52·2	58·1	64·7	63·4	60·0	57·4	50·3	47·8	52·6
***Predominantly A.I.S. Centres ..	44·6	45·0	44·6	49·4	53·0	56·8	63·2	61·4	63·8	44·7	50·5	48·9	52·2
All Centre Average 1954–1955 ..	43·2	45·3	43·6	46·1	49·9	54·3	61·1	61·4	60·3	55·2	50·6	46·2	51·4

† Samples unavailable.

Differences in monthly values are relatively large in each centre due to marked seasonal trends. Thus yearly averages have not been calculated for centres with incomplete samples. However, the smaller differences between centres in any one month permitted the calculation of monthly and yearly averages for districts without introducing appreciable errors. Monthly and yearly averages of centres with similar breed distribution are also presented.

(2) Seasonal Trends.

The seasonal trends in the carotene, vitamin A and total vitamin A contents in butterfats are shown in Figs. 2–13 for individual centres and in Fig. 14 as an average for all centres. In addition, butter production is presented in Fig. 14 as a monthly percentage of the total annual production. These production percentages have been calculated from individual factory production and are given as an average for all centres.

Most centres showed the same pattern, with peaks of similar magnitude occurring at approximately the same time of the year. The exception was Malanda (Fig. 2), where the annual average vitamin A and total vitamin A potency were lower than for any other centre and the values showed less well defined peaks.

(*a*) *Maximum Values.*—Maximum values for carotene in butterfats occurred generally between the end of winter and mid-spring (August–October).

Maximum values for vitamin A and total vitamin A occurred between midwinter and early spring (July to September).

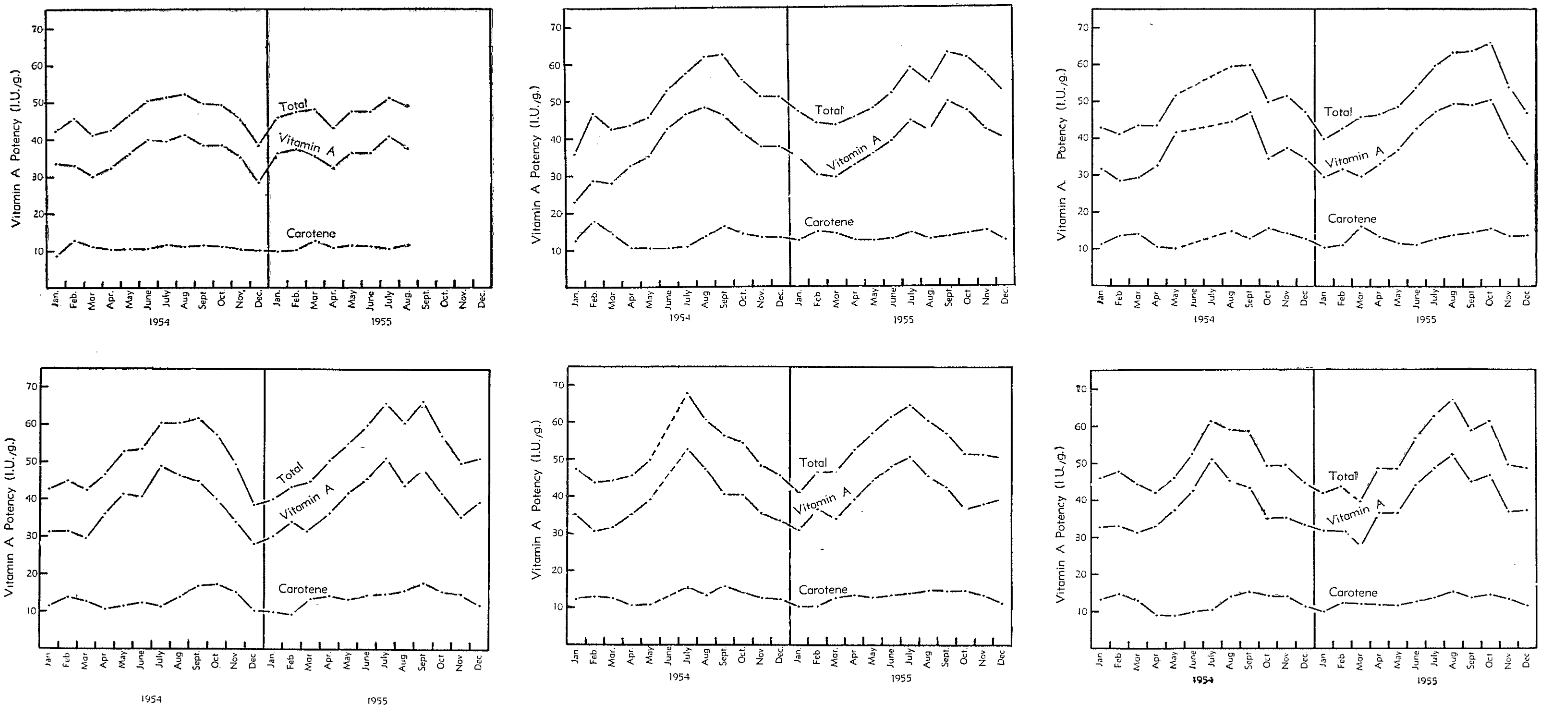
Maximum values for vitamin A preceded those of carotene by one month in both years.

(*b*) *Minimum Values.*—In 1954, minimum values for carotene in butterfat occurred between mid-autumn and early winter (April–June).

In 1955 they occurred in summer (December 1954–February 1955).

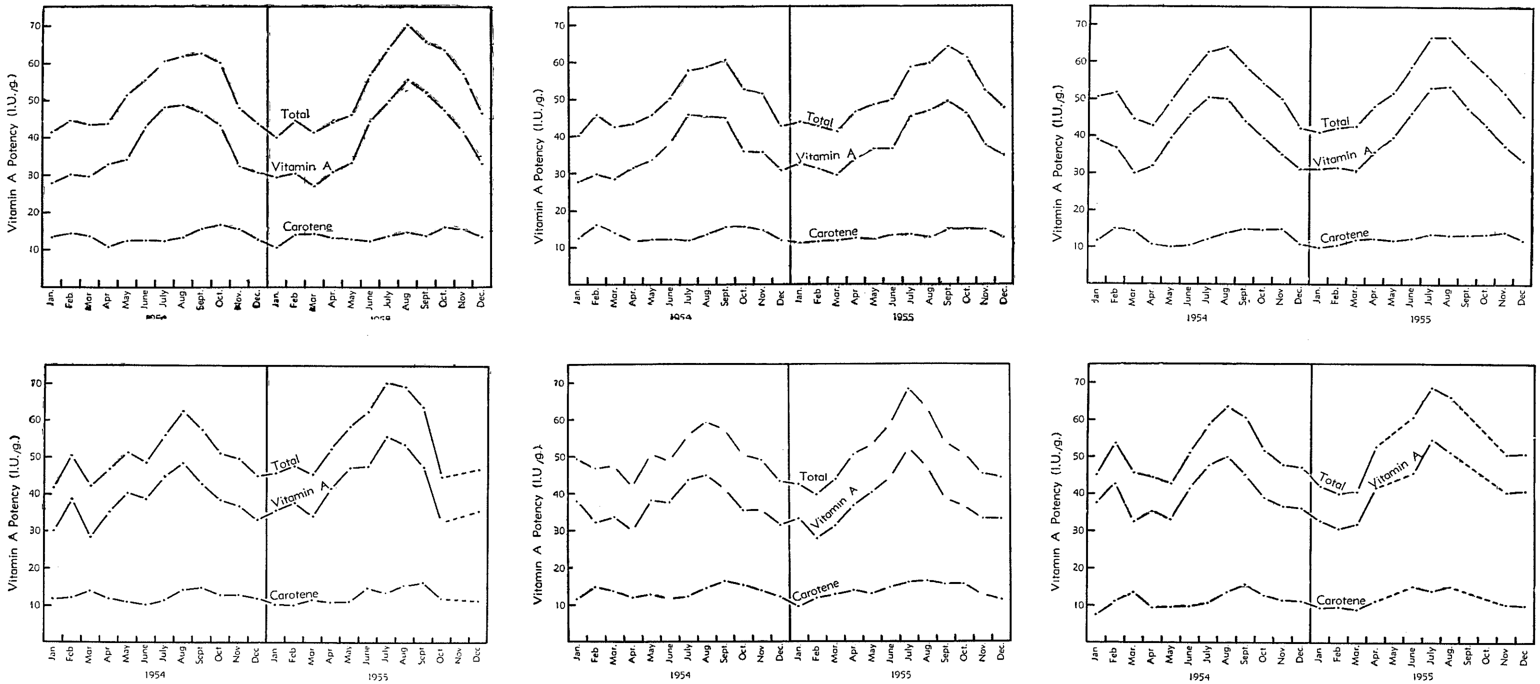
In both years, minimum values for vitamin A and total vitamin A potency occurred between midsummer and early autumn (January–March).

Minimum vitamin A values preceded minimum carotene values by three months in 1954. In 1955, they succeeded them by one month.



Figs. 2–7.

Seasonal Trends in Carotene, Vitamin A and Total Vitamin A Contents of Butterfats from (left to right) Malanda, Gladstone, Biggenden, Murgon, Kingaroy and Grantham.



Figs. 8–13.

Seasonal Trends in Carotene, Vitamin A and Total Vitamin A Contents of Butterfats from (left to right) Gympie, Caboolture, Beaudesert, Chinchilla, Toowoomba and Warwick.

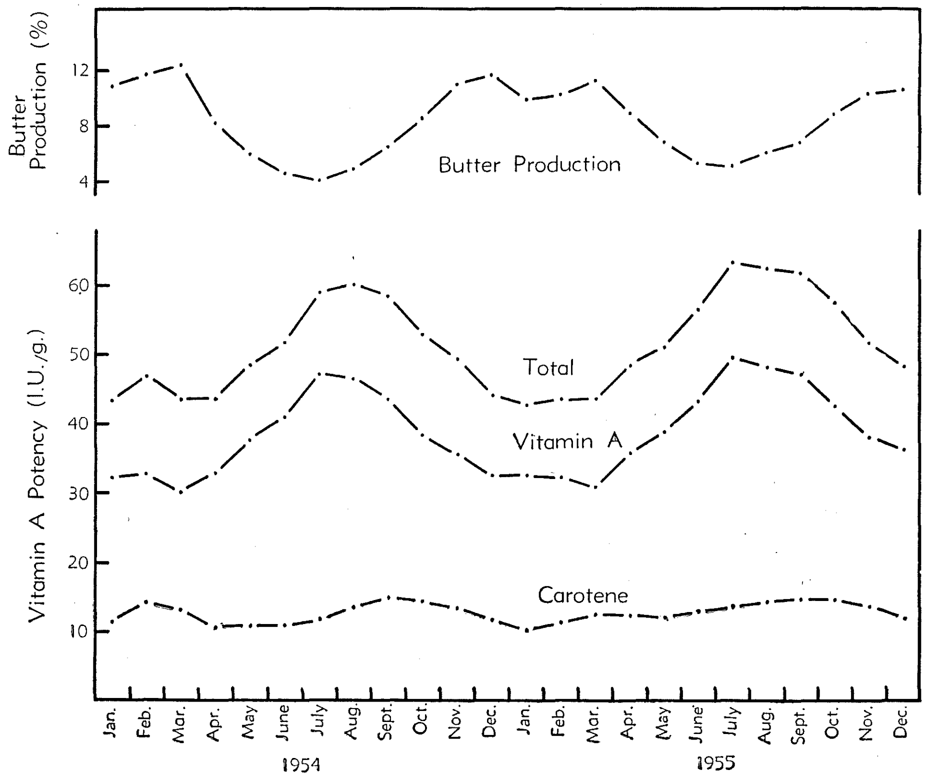


Fig. 14.

Seasonal Trends in the Carotene, Vitamin A and Total Vitamin A Contents of Queensland Butterfats. Butter production is shown as monthly percentages of the total annual production (average of 12 centres).

(3) Weighted Mean Annual Contents of Carotene, Vitamin A and Total Vitamin A.

Although butter production in Queensland follows a seasonal trend (Fig. 14), the difference in production levels between successive fortnightly samples is not great. Thus the monthly carotene, vitamin A and total vitamin A contents of butterfats have not been weighted for production. The weighted mean annual contents for these values do not vary greatly from the unweighted means, as shown in Table 4.

Table 4.

WEIGHTED AND UNWEIGHTED MEAN ANNUAL CONTENTS OF CAROTENE, VITAMIN A AND TOTAL VITAMIN A IN QUEENSLAND BUTTERFATS.

—	Unweighted Mean Annual Content in Butterfat. (I.U./g.)		Weighted Mean Annual Content in Butterfat. (I.U./g.)	
	1954.	1955.	1954.	1955.
Carotene	12·7	13·0	12·7	12·8
Vitamin A	37·6	39·6	35·8	38·2
Total Vitamin A Potency	50·3	52·6	48·5	51·0

(4) Xanthophyll Content of Butterfats.

From July 1954 to December 1955, total carotenoids were determined in butterfats. The difference between total carotenoids and carotene was recorded as xanthophyll. The average monthly values for the 12 centres are presented in Fig. 15.

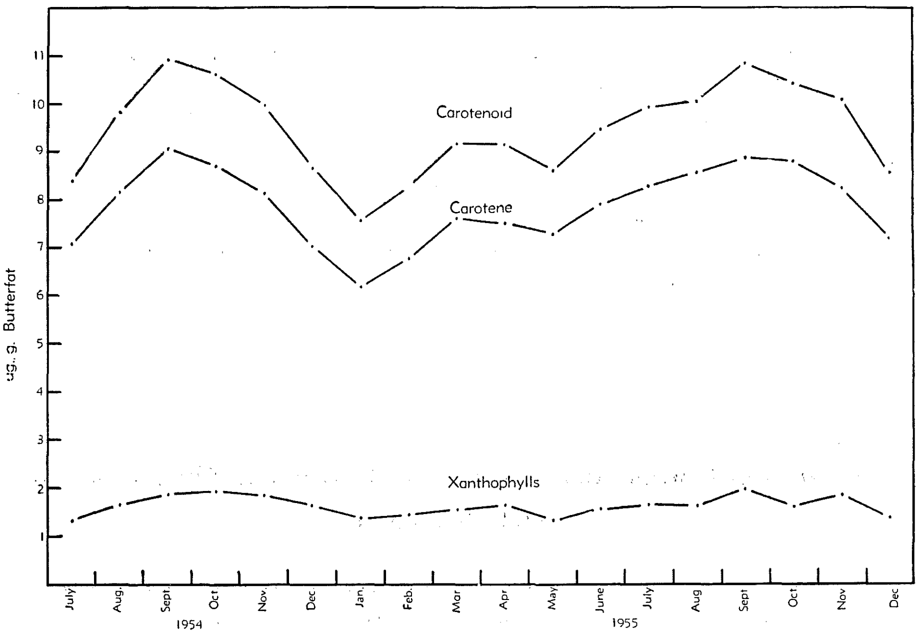


Fig. 15.

Xanthophyll, Carotene and Carotenoid Contents of Queensland Butterfats (Average of 12 Centres).

(5) Proportion of Total Vitamin A Potency in Butterfats Due to Carotene.

The seasonal variations in the total vitamin A potency of butterfats were much greater than the variations in carotene (Fig. 14). The proportion of the total vitamin A potency due to carotene is thus inversely correlated with the total vitamin A potency. This proportion can be obtained from Tables 1 and 3. The mean value for all the 12 centres was 25·2 per cent. in 1954 and 24·7 per cent. in 1955.

(6) Variations Between Centres and Districts.

With the exception of Malanda, differences between centres and between districts were small in terms of carotene, vitamin A and total vitamin A content of butterfats. The values for Malanda butterfat were lower than for any other centre in 1954. The same trend was apparent in 1955, although average annual values were not estimated because samples covering the last four months of the year were unsuitable for analysis.

(7) Variations Between Years.

Climatic conditions for the two years of the survey promoted good pasture growth. Marked variations in the analytical data from one year to the other were not obtained. In fact, the annual averages for carotene, vitamin A and total vitamin A potency of butterfat were similar for most centres in both years.

(8) Variations Between Breeds.

(*a*) *In Carotene Content of Butterfat.*—The dairy cattle population of the 12 centres consisted predominantly of two breeds: Jersey and A.I.S. cattle. In Table 5, the estimated breed distribution is given for each centre, together with mean values for the proportion of total vitamin A potency due to carotene and mean values for the carotene content of butterfats.

Table 5.

Breed Distribution in Each Centre, Mean Values for Proportion of Total Vitamin A Potency Due to Carotene in Butterfats, and Mean Values for Carotene Content of Butterfats.

Centre.	Breed.			1954.		1955.	
	Jersey.	A.I.S.	Mixed.	Proportion Total Potency due to Carotene.	Carotene. I.U./g. Butterfat.	Proportion Total Potency due to Carotene.	Carotene. I.U./g. Butterfat.
	%	%	%	%		%	
Gladstone ..	98	..	2	26·1	13·2	25·9	13·5
Caboolture ..	80	15	5	27·3	13·4	25·3	13·0
Gympie	75	20	5	26·5	13·6	25·7	13·7
Kingaroy ..	50	50	..	25·2†	12·9†	24·3	13·0
Biggenden ..	50*	40	10	..	..	25·0	13·1
Beaudesert ..	47	50	3	24·7	12·9	23·7	12·5
Toowoomba ..	40	58	2	26·6	13·3	26·3	13·5
Murgon	40	60	..	25·9	13·2	25·7	13·8
Grantham ..	40	60	..	24·6	12·3	24·4	12·7
Malanda	35	65	..	23·3	10·8	..	..
Chinchilla ..	25	75	..	24·5	12·3	22·8†	12·6†
Warwick ..	25	75	..	22·1	11·3	..	..

* Consisting of 40 per cent. Jersey, 10 per cent. Guernsey breed.

† Average of 11 months.

It appears from Table 5 that there is a relationship between breed and the proportion of total vitamin A due to carotene. This is examined statistically in Table 6A.

Table 6A.

Summary of Analyses of Variance—Proportion of Total Vitamin A Potency in Butterfats due to Carotene and Percentage Jersey Breed.

Source of Variation.	1954.		1955.	
	Degrees of Freedom.	Mean Squares.	Degrees of Freedom.	Mean Squares.
Linear Regression	1	174·005†	1	45·437
Deviations	9	17·566	8	11·658
Between Centres	10	33·210	9	15·411
Regression Coefficient ..		0·0508		0·0290

† Significant at 5 per cent. level.

In Table 6B the relationship between breed and carotene content of butterfat is examined statistically.

Table 6B.

SUMMARY OF ANALYSES OF VARIANCE—CAROTENE CONTENT OF BUTTERFATS AND PERCENTAGE JERSEY BREED.

Source of Variation.	1954.		1955.	
	Degrees of Freedom.	Mean Squares.	Degrees of Freedom.	Mean Squares.
Linear Regression	1	40·035†	1	3·129
Deviations	9	6·847	8	2·487
Between Centres	10	10·166	9	2·559
Regression Coefficient ..		0·0243		0·0076

† Significant at 5 per cent. level.

The variance within districts was not calculated due to the marked seasonal trends encountered both in the carotene and in the total vitamin A content of butterfats. For this reason also, centres with more than one monthly value missing were excluded from the analysis (Table 5).

In 1954, butterfat from centres with predominantly Jersey cattle contained a significantly greater proportion of total vitamin A potency due to carotene and a significantly greater carotene content compared with centres with predominantly A.I.S. cattle. In 1955, there were no significant correlations between these variates.

There was no correlation between breed and either the vitamin A or the total vitamin A potency of butterfats.

(*b*) *In the Proportion of Carotene to Total Carotenoids in Butterfats.*—The mean value for the proportion of carotene to total carotenoids, together with the estimated breed distribution, is given for each centre in Table 7. The proportion of carotene to total carotenoids ranged from 74·1 to 94·5 per cent., the average being 82·7±2·8 per cent.

Table 7.

BREED DISTRIBUTION IN EACH CENTRE AND MEAN VALUES FOR THE PROPORTION OF CAROTENE TO TOTAL CAROTENOIDS IN BUTTERFATS.

Centre.	Breed.			Ratio Carotene to Carotenoids.	Number of Samples.
	Jersey.	A.I.S.	Mixed.		
	%	%	%	%	
Gladstone	98	..	2	80·4	17
Caboolture	80	15	5	79·5	18
Gympie	75	20	5	79·9	18
Kingaroy	50	50	..	83·6	18
Biggenden	50*	40	10	80·1	17
Beaudesert	47	50	3	83·9	18
Toowoomba	40	58	2	85·6	18
Murgon	40	60	..	82·2	18
Grantham	40	60	..	84·6	18
Malanda	35	65	..	81·0	15
Chinchilla	25	75	..	85·5	17
Warwick	25	75	..	86·5	16

* Consisting of 40 per cent. Jersey, 10 per cent. Guernsey breed.

The relationship between breed and the proportion of carotene to total carotenoids is examined statistically in Table 8. There was no seasonal trend in the proportion, but there was variation within districts.

Table 8.

SUMMARY OF ANALYSES OF VARIANCE—PROPORTION OF CAROTENE TO TOTAL CAROTENOIDS IN BUTTERFATS AND PERCENTAGE JERSEY BREED.

Source of Variation.	Degrees of Freedom.	Mean Squares.
Linear Regression	1	666·97††
Deviations	10	53·92††
Between Centres	11	109·66††
Within Centres	196	7·62
Regression Coefficient ..		−0·0833

†† Significant at 1 per cent. level.

Butterfat from centres with predominantly Jersey cattle contained a significantly smaller proportion of carotene to total carotenoids than centres with predominantly A.I.S. cattle.

(9) Comparison of Total Vitamin A Potency of Queensland Butterfat with Values from Other Regions.

When comparing the annual average total vitamin A potency of butterfat and butter obtained in this survey with values for other regions, consideration must be given to climatic conditions. In Queensland, cattle graze throughout the year and pastures are the main source of feed.

In Europe and in most parts of the United States of America, cattle are stall-fed in winter. In the absence of continuous grazing the potency of the winter butterfat falls (Table 10), resulting in a lowering of the annual average vitamin A potency. In Table 9, the average total vitamin A potency of butterfat and butter is presented for some regions where stock graze continuously throughout the year.

Table 9.

AVERAGE TOTAL VITAMIN POTENCY OF BUTTERFAT AND BUTTER FROM SOME REGIONS WHERE GRAZING IS PRACTISED THROUGHOUT THE YEAR.

Region.	Year.	Vitamin A Potency. I.U./g. Butterfat.	Vitamin A Potency. I.U./lb. Butter†.	Proportion Potency due to Carotene.	Authority.
Victoria††	1947–48	45·2	16800	35·0–40·0	Farrer *et al.* 1949
New Zealand ..	1946–48	45·0	16740	36·8	McDowell and McDowall 1953
Queensland ..	1954–55	51·4	19100	24·9	..

† Calculated as butter containing 82 per cent. butterfat.

†† These values are estimated from the data presented in Table 1 of this paper. They have been corrected for a 7·5 per cent. analytical loss of vitamin A to conform with the succeeding values on the assumption that 37·5 per cent. of the total vitamin A potency was due to carotene.

It is of interest to compare the vitamin A potency of winter and summer butter in different countries. The data for New Zealand, Great Britain, Sweden and Denmark have been reproduced from McDowell and McDowall (1953) and are presented in Table 10, together with data from the United States of America and Queensland.

Table 10.

COMPARISON OF TOTAL VITAMIN A POTENCIES OF BUTTER IN DIFFERENT COUNTRIES.

Country.	Total Vitamin A Potency expressed as			
	I.U./g.		I.U./lb.	
	Winter Butter.	Summer Butter.	Winter Butter.	Summer Butter.
New Zealand	41·9	33·8	19,010	15,330
Great Britain†	18·5	29·0	8,390	13,150
Sweden**	15·0	24·2	6,800	10,980
Denmark***	16·5	33·1	7,480	15,010
U.S.A.*	20·1	32·9	9,120	14,900
Queensland††	45·4	34·7	20,590	15,740

† Calculated from values published by Thompson, Ganguley, Mawson & Kon (1949) for carotene and vitamin A contents of milk in Great Britain. The assumption has been made that 80 per cent. of the total carotenoids in the summer milks and 75 per cent. of the total in the winter milks examined was active carotene.

** Platon & Swartling (1944).

*** Fridericia (1947).

* Recalculated from the uncorrected values published by Cary (1947) and based on a factor of 3·33 instead of 4.0 for the conversion of vitamin A expressed in micrograms into international units. It was assumed that 20 per cent. of the potency was due to carotene for both winter and summer butter.

†† These values are uncorrected for analytical losses to conform with the preceding values and are calculated on the basis of butter containing 82 per cent. butterfat.

(10) Correlation of Butter Production Ratio and Total Vitamin A Potency of Butterfat.

Weekly butter production records were obtained from each factory. The monthly butter production for each centre was assessed from these records and expressed as a percentage of the annual production. The monthly percentages of the 12 centres were then combined and expressed as an overall average for each month of the particular year. Finally, the monthly butter production percentages were averaged for the two years.

Production percentages are to some extent a function of the number of cows lactating in any one month. To relate monthly production to the total vitamin A potency of butterfat, some means of correction for the different number of cows lactating per month had to be considered.

This was achieved through access to herd recording data for the years 1948–1955, comprising records from one to three areas in each centre. The number of cows lactating per month was obtained by reference to the number calving per month and their average length of lactation. The number lactating per month was expressed as a percentage of the total number lactating per year. The monthly percentages of the 12 centres were then combined and expressed as an overall average for each month. The cows in the herd recording scheme were considered representative of all cows in a centre, though in most cases they were only a small percentage of the population.

The production percentages were then adjusted by taking into account the proportion of cows lactating per month in the following manner:

$$\text{Butter production ratio} = \frac{\text{Percentage butter produced in any one month}}{\text{Percentage cows lactating in same month}}$$

In Fig. 16, the production ratio is presented together with the total vitamin A potency as a 2-year average for the 12 centres. There is a highly significant inverse correlation ($r = -0{\cdot}754$, $P = < 0{\cdot}01$) between the values.

(11) Correlation of the Proportion of Cows Calving and the Total Number of Lactating Cows in Any One Month and Total Vitamin A Potency of Butterfat.

This proportion was determined from the herd recording data from each centre and expressed in monthly percentages as an average for 12 centres.

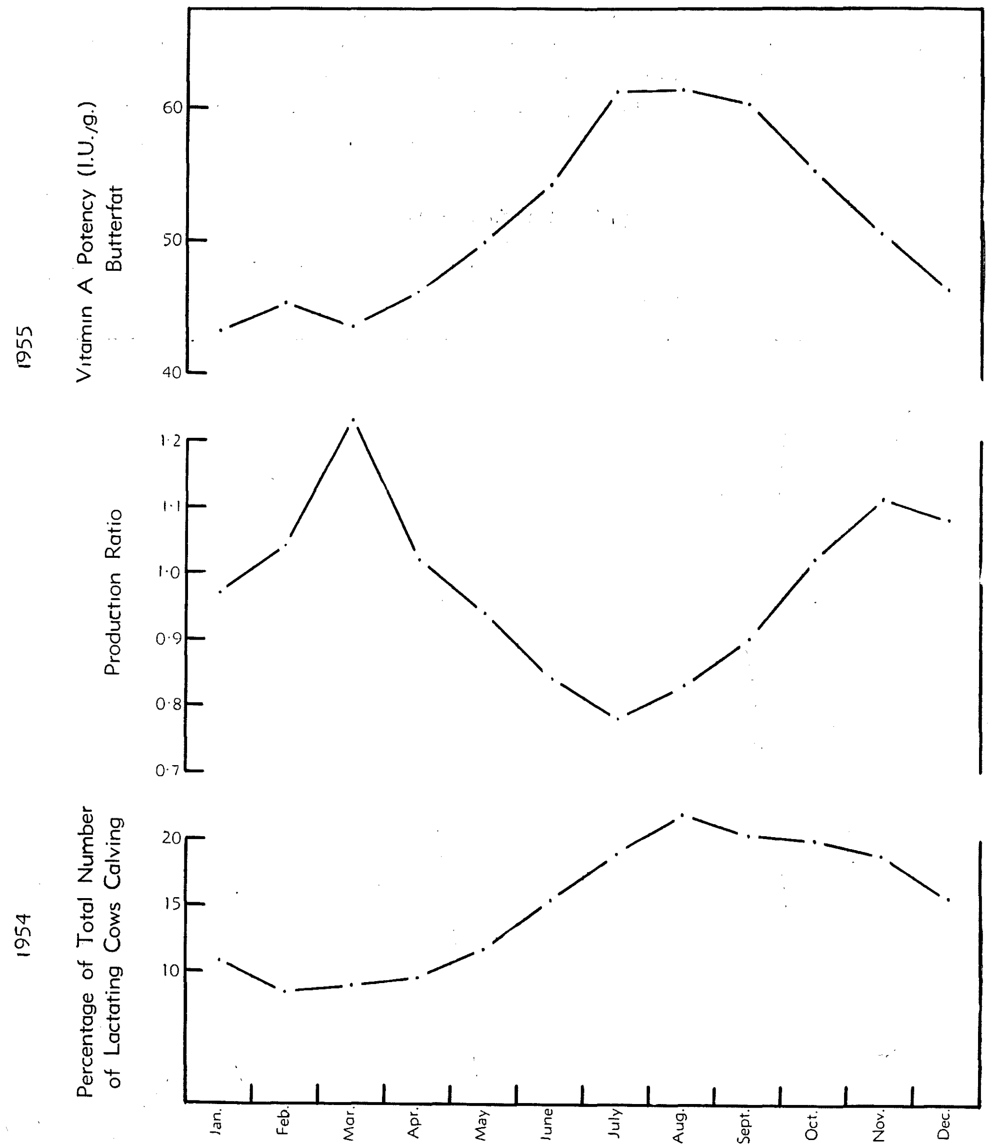


Fig. 16.

Production Ratio, Percentage of Total Lactating Cows Calving and Total Vitamin A Potency of Queensland Butterfats (Average of 12 Centres).

Seasonal calving is practised to a limited extent in Queensland. The average number of cows calving per month in the 12 centres ranged from 5·2 per cent. in April to 12·4 per cent. in October. Although the percentage cows calving per month is highest in October, the proportion of cows calving to the total number of lactating cows is highest in August.

The lactation curve in Fig. 16 varies uniformly and each successive month is a reflection of the proportion of cows in early and late lactation. The total vitamin A potency curve represents the concentration of the butterfat from cows in these proportions. There is a highly significant positive correlation ($r = 0{\cdot}922$, $P = < 0{\cdot}01$) between the values.

(12) Rainfall Pattern.

The monthly distribution of rainfall is shown in Fig. 17 as an average for the 12 centres.

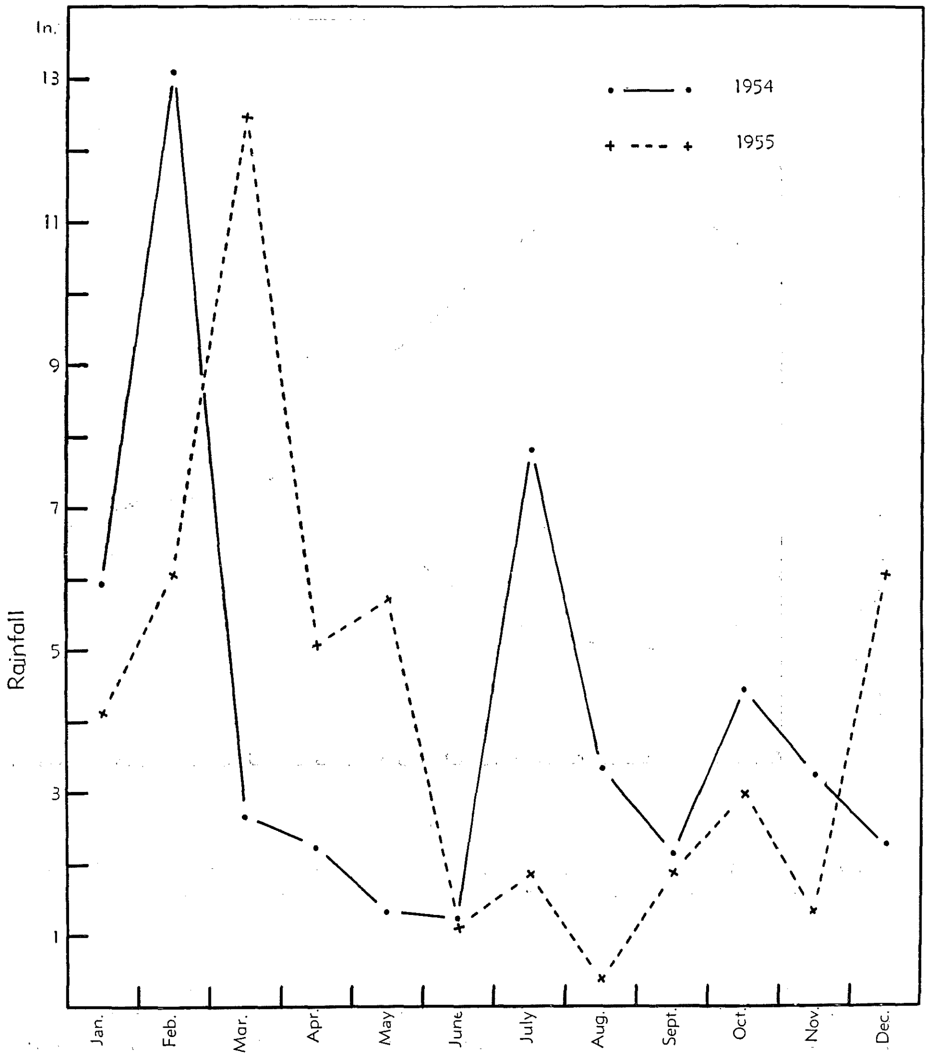


Fig. 17.

Monthly Rainfall Distribution in 1954 and 1955 (Average of 12 Centres).

IV. DISCUSSION.

With grazing throughout the year as practised in Queensland, a uniformly high total vitamin A potency in butterfat might be expected in years of average rainfall. However, marked seasonal trends were found, with maximum values occurring between midwinter and early spring and minimum values between midsummer and early autumn. Similar seasonal trends have been shown for New Zealand butterfats by Barnicoat (1947), McDowell and McDowall (1953) and McGillivray (1956).

Similarly definite seasonal trends are apparent in the vitamin A potency of European and American butterfats; they have been attributed largely to the lower carotene content of winter feed (Lord 1945; Cary 1947; Wiseman and Sheperd 1949; Hibbs, Krauss and Monroe 1949). Higher carotene content of New Zealand winter pastures coincided with higher carotene and vitamin A content in butterfats, and lower carotene content of summer pastures coincided with lower values in butterfats. However, pasture carotene was found on both theoretical and experimental grounds not to be responsible for the fluctuations in New Zealand butterfats (McGillivray 1952; McDowell and McDowall 1953; McGillivray 1956).

In Queensland, the period of maximum rainfall and pasture growth is in summer when the vitamin A potency of butterfats is at a minimum. Limited analyses of pastures (Gartner, unpublished data) showed that carotene content is not a limiting factor to vitamin A potency of Queensland butterfats in years of normal rainfall.

The range between maximum and minimum values in the average monthly carotene values of Queensland butterfats was less than found in New Zealand butterfats by McDowell and McDowall (1953). This was due to the lower maximum values found in Queensland. The range in the vitamin A contents was comparable, the higher maximum values in Queensland being offset by the lower minimum values in New Zealand.

The xanthophyll contents of Queensland butterfats were determined over a period of 18 months. Levels remained relatively constant and were comparable with values determined in New Zealand by McGillivray (1956) over a period of six months. Subsequently, McGillivray (1957) in observations over a period of 10 months showed higher maximum values in August and November.

There were no marked differences in the carotene and vitamin A contents of butterfats from the 12 centres either in 1954 or in 1955. The values for Malanda butterfat were slightly lower in both years than for any other centre. The significance of this difference is not known. The average total vitamin A potency of Queensland butter in both summer and winter was higher than values published for other countries.

The results of this survey are considered in relation to the following data:

Influence of Breed Distribution.—The average breed distribution of the 12 centres was 50 per cent. predominantly Jersey, 47 per cent. predominantly A.I.S., and 3 per cent. mixed breeds. The average proportion of total vitamin A potency in butterfats due to carotene for all centres was 25·2 per cent. in 1954 and 24·7 per cent. in 1955. Farrer *et al.* (1949) found the total potency due to carotene was usually 35–40 per cent. McDowell and McDowall (1953) found it averaged 37 per cent. They attributed this high proportional contribution of carotene to the preponderance of the Jersey breed (about 80 per cent.) in New Zealand dairy herds.

It is characteristic of the Channel Island breeds that in comparison with cows of other breeds they are less efficient converters of ingested carotenoids to vitamin A. This is reflected in higher blood plasma carotenoids (Sutton and Soldner 1945; Wise, Atkeson, Caldwell, Parrish and Hughes 1947) and a greater proportion of total vitamin A potency due to carotene in milk fat (Parrish, Martin, Atkeson and Hughes 1946; Barnicoat 1947; Krukovsky, Whiting and Looski 1950).

The ability of the A.I.S. breed as compared with the Jersey breed to convert carotene to vitamin A was examined. The first year's results showed that the greater the ratio of Jersey to A.I.S. breeds, the greater both the proportion of total vitamin A potency due to carotene and the amount of carotene in butterfat. The centres Malanda and Warwick, containing predominantly A.I.S. cattle, were excluded from the statistical analyses in the second year due to incomplete samples. A lack of significance in that year was possibly due to an absence of values from these two centres. There was no correlation between breeds and the vitamin A or total vitamin A potency of butterfats.

Butterfats from centres containing predominantly Jersey cattle contained a significantly smaller ratio of carotene to total carotenoids as compared with centres containing predominantly A.I.S. cattle. Variations in the ratio of carotene to carotenoids in butterfats have been recorded (Berl and Paterson, 1943; Chanda, Clapham and Owen 1954) but not related to breed differences.

Thus the A.I.S. breed, as compared with the Jersey breed, secretes less carotene and less carotenol pigments in butterfat, indicating more efficient utilisation of ingested carotenoids.

Influence of Production Ratio.—McDowell and McDowall (1953) concluded there was no evidence to connect the changes in carotene and vitamin A content of New Zealand butterfat with the rise in milk and fat yield during the late-spring to early-summer period, or with the fall in milk and fat yield during the autumn or during periods of drought. McDowell (1956) reviewed the literature on the relationship between stage of lactation and vitamin A potency of butterfats. Various workers found that the vitamin A content of butterfats either rose, fell or remained unaltered towards the end of lactation (i.e., when production is low). McDowell (1956) found that the trend in carotene and vitamin A content in butterfat is seasonal with cows calving in spring and autumn. The evidence regarding increased concentrations during autumn is not as definite when considering an end-of-lactation effect. McGillivray (1956) could not determine from his results on factory butterfats whether the increase in concentration of carotene and vitamin A during autumn was a seasonal trend or an end-of-lactation effect. Subsequently McGillivray (1957) suggested from his findings on individual cows that autumn increases may be due more to an end-of-lactation than to a seasonal effect.

Corrections in butter production data to account for the different number of cows lactating per month were achieved by using the ratio of percentage butter produced in any one month to percentage cows lactating in the same month.

There was a highly significant negative correlation between production ratio and the total vitamin A potency of Queensland butterfats. The influence of production ratio may account for some of the variations in butterfat potencies throughout the year or part of the year.

Influence of Proportion of Cows Calving to the Total Number of Lactating Cows in Any One Month.—When comparing the effect of stage of lactation on the carotene and vitamin A contents of butterfats, New Zealand workers (McDowell and McDowall 1953; McDowell 1956) presented lactation data in the form of percentage cows calving per month.

In any survey, each factory sample of butter is proportionately more representative of cows in early lactation than of those in late lactation, due to the higher average production of the former. The proportion of cows calving to the total number of lactating cows in any one month is therefore a better index of the influence of stage of lactation on the observed total vitamin A potency of butterfat and has been used here.

It is well known that colostrum is high in carotene and vitamin A. McDowell (1956) showed that high values may persist in post-colostral fat for as long as 10–12 days after calving. Thompson and McGillivray (1957) found that concentrations in the milk fat of heifers reached steady levels after about 10–14 days, compared with 6–7 days for cows.

A highly significant positive correlation was found between the proportion of cows calving to the total number of lactating cows in any one month and total vitamin A potency of Queensland butterfats. This could be due partially to the inclusion in butterfat of post-colostral fat of high vitamin A potency.

Influence of Nutrition.—Although the proportion of cows calving to the total number of lactating cows increases from February to July, the production ratio decreases (Fig. 16). As the proportion decreases from August to February, the production ratio increases. This is due to the effect of season on pasture growth, which markedly influences the plane of nutrition in grazing animals.

Influence of Rainfall.—With the exception of Malanda, the annual rainfall for each centre was greater in 1954 and 1955 (Fig. 17) than its mean annual rainfall for either the period 1911–1940 (Bureau of Meteorology, Melbourne) or 1921–1950 (Coaldrake and Bryan 1957). In Malanda 60·11 in. were recorded in 1954, against a long-term average of 66·62 in.

This above-average rainfall resulted in good growth of pasture. It has been shown that butterfat production is related to the plane of nutrition. It has also been shown that marked seasonal trends in the total vitamin A potency of butterfats are inversely related to production. Thus the relationship of rainfall to the vitamin A potency of butterfats is only through its influence on nutrition and production.

Influence of Tocopherol Content and Botanical Composition of Pastures.—The effect of pasture tocopherols on the seasonal trends in New Zealand butterfats was studied by McGillivray (1952). The supplementation of α–tocopherol to cows grazing summer pastures increased both the carotene and the vitamin A content of butterfat to a winter level. It was postulated that low summer vitamin A potencies of New Zealand butterfats may be due to low tocopherol rather than to low carotene levels in pasture and may be associated with the high percentage of clover in summer pasture. McGillivray (1956) found a highly significant correlation between both tocopherol and total vitamin A potency in butterfat.

The apparent seasonal trend in the availability of carotene from New Zealand pastures was further investigated by Worker and McGillivray (1957). Using three sets of monozygotic twins they showed that diets high in white clover (approximately 70 per cent. against approximately 36 per cent.) significantly decreased the vitamin A potency of butterfat. They suggested that this may be due to the low tocopherol content of clover relative to grass, the possibly lower oleic acid content of clover, or some factor or factors present at a time when clover happens to be the dominant pasture species.

A short-term trial was carried out in Queensland (Gartner, unpublished data) to examine the effects of dl–α–tocopheryl acetate supplementation to a set of twin Jersey cows grazing summer pastures. One twin was used as an unsupplemented control. In this limited trial there was no evidence to indicate increased secretion of vitamin A in butterfat by supplementation of 2 g. dl–α–tocopheryl acetate per day. The influence of pasture species, specifically white clover, was not investigated. In contrast with the New Zealand pastures investigated, the proportion of white clover in this predominantly paspalum pasture was negligible at the time of this trial.

V. ACKNOWLEDGEMENTS.

Thanks are due to officers of the Division of Dairying, Queensland Department of Agriculture and Stock, who submitted the butter samples and to Mr. P. B. McGovern, M.A., B.Sc. (Departmental Senior Biometrician) for guidance with the statistical analyses.

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