CHARACTERISTICS AND UNSATURATED FATTY ACID COMPOSITION OF COLOSTRUMFAT.

By

Lamberthus van den Berg, l.i.

The University of Manitoba

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(Abstract of Thesis)

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The composition of colostrumfat was investigated to determine to what extent colostrumfat differed from normal milkfat, and how these differences change with the number of milkings after calving. Spectrophotometric methods were used to determine the unsaturated fatty acid content.

Colostrumfat from the first milkings is characterized by a higher degree of unsaturation, a low saponification value, a low Reichert-Meissl value and a low Polenske value. The conjugated fatty acids occur in normal amounts, while the contents of the non-conjugated dienoic, tetraenoic and pentaenoic fatty acids are unusually high. The saponification value and the Reichert-Meissl value return to normal level rapidly, while the iodine value, the Polenske value and the contents of the non-conjugated fatty acids are not yet normal on the tenth milking after calving with most cows.

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INTRODUCTION.

Colostrum is known to differ in many respects from normal milk. Almost all constituents of the milk are present in abnormal amounts. The protein content is high, due mainly to the globulin fraction. The ash content and the composition of the ash vary greatly from the relatively constant values reported during the rest of the lactation period. The fat content is usually normal (18, 35, 42).

In addition to the gross composition of colostrum the properties of the constituents themselves are of interest. Much interesting research has been done on the significance of the globulin fraction of colostrum. Fewer investigations have been performed on the composition of the fat in colostrum although its composition is of interest because of its influence on the seasonal variations in the composition of milkfat and in the physiological process of fat synthesis in the udder. Also of interest is the question of whether the newborn calf needs some special fatty acids in its diet. Recently methods have been developed which make it possible to do serial investigations on the poly-unsaturated fatty acid contents of fats and oils. Most of these methods involve absorption measurements in the ultraviolet region. However infrared absorption spectra are also of use in studying unsaturated fatty acids (47).

Preliminary experiments, (41) conducted in this laboratory showed that colostrum fat contains large amounts of poly-unsaturated fatty acids which decrease rapidly with the number of milkings after calving. It seemed worthwhile to investigate the matter more thoroughly, to determine if this is true generally and if so, whether it is true for all such fatty acids or only for certain ones.

This thesis reports the results of this investigation.

LITERATURE REVIEW.

1. Analysis of milkfat and newly identified fatty acids.

Formerly fats could be characterized by certain numbers such as Reichert-Meissl value, Polenske value, Kirchner value, iodine value and saponification value. These tests give an indication of the amounts of certain types of fatty acids present, for example volatile fatty acids or unsaturated fatty acids. The isolation of, and analysis for, individual fatty acids was very difficult due to technical factors, although the principle of the method now in use was well known and easy. It consisted of converting the fatty acids to the methyl- or ethylesters and distilling them in vacuo with fractionating facilities, so that the fractions do not contain more than 2 or 3 fatty acid esters. The esters can then be characterized by the saponification equivalent, molecular weight and iodine and thiocyanogen value.

However this method was improved by Hilditch and coworkers (25) and is now in use in many laboratories as a valuable tool in investigating fats and oils. Spectrophotometric analyses are coming into use to provide additional information on the poly-unsaturated fatty acids (8, 9, 47).

With the improvement of the isolation techniques, many new fatty acids were found. The poly-unsaturated fatty acids were discovered and fatty acids with more than 18 carbon atoms were isolated

(12, 13, 20). Unsaturated fatty acids with smaller chain length than oleic (down to 10 carbon atoms) were also isolated. So the presence in butterfat of decenoic, dodecenoic, tetradecenoic, hexadecenoic, octadecadienoic (Δ 9-12, which is not the same as linoleic acid), octadecatrienoic (Δ 9-12-15, or linolenic acid) and arachidonic (Δ 5-8-11-14, eicosatetraenoic acid) was proven. Also vaccenic acid (Δ 11-12, elaidic acid), once thought to be a growth promoting fatty acid (32, 33) is present in butter from 0.50 to 0.70% (21).

Although spectrophotometric evidence exists for the presence of a conjugated dienoic acid, this acid has never been identified. It is not impossible that the dienoic absorption (232 mu) is due to two conjugated double bonds in a non-conjugated trienoic, tetraenoic or pentaenoic acid (36). Besides, spectrophotometric evidence is available for the presence of small amounts of fatty acids with 5 and 6 double bonds (45, 47), which have absorption maxima at 348 and 375 mu respectively.

Recently Hansen and Shorland (23) isolated 12-methyl-tetradecanoic acid, 13-methyl-tetradecanoic acid and 12-methyl-tridecanoic acid, as first proof of the occurrence of branched chain fatty acids (some with an odd number of carbon atoms) in milkfat.

2. Normal composition of milkfat and its variations due to feed and season.

Before considering the composition of colostrumfat it is

pertinent to discuss the composition of normal milkfat with its usual variations due to feed and season.

Detailed analysis of some samples of milkfat are reproduced in Table I*).

Palmitic and oleic acids are the chief component fatty acids of butterfat. The palmitic acid content is more constant than that of oleic acid. A comparison of samples 4 and 5 reveals that palmitic acid decreases from 26.7 to 24.0 mol %, (a decrease of about 11%) while oleic acid increases from 22.4 to 27.7 mol % (an increase of about 23%). The acid that balances the oleic acid increase is largely myristic acid. Other figures given by Hilditch (25) indicate that oleic acid content changes are mostly balanced by the lower saturated fatty acids and stearic acid. Consequently a high iodine value is accompanied by a low Reichert-Meissl value. This is also evident in the results of an investigation of Hilditch and Sleightholme (28), given in Table II, and in the results of Hansen and Shorland (22), Table III.

The volatile fatty acids form an appreciable amount of the total fatty acids of milkfat. Animal depot fats either do not contain these fatty acids or contain them only in very small amounts (25). Buffalo milkfat (1) and cow milkfat are known to contain the highest amount of lower fatty acids of all milkfats investigated up to the present time. Human milkfat for instance contains only a small amount of volatile fatty acids (8).

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*) All tables and graphs are contained in the Appendix.

The differences between the analyses of Jack and Henderson (30) and those of Hilditch and coworkers (27), especially remarkable in the oleic acid and palmitic acid contents, cannot be explained, as the origin of the fat investigated by Jack and Henderson is not known. The oleic acid content however is so low that the fat must have been obtained under unusual feeding circumstances. Compared with the sample 4, having also a low oleic acid content, the differences in oleic acid contents seem to be balanced mainly in the lauric and myristic acid contents, and only to a small extent in the palmitic and stearic acid contents.

The monoenoic unsaturated fatty acids, with 10 to 16 carbon atoms, form a considerable part of the total unsaturated acids (3 to 6% by weight or 3 to 7 mol % of the total fatty acids). The contents seem to be a little higher when the oleic acid is low and vice versa. The results show clearly that it is not very accurate to calculate the amount of monoenoic acids as oleic acid. The real monoenoic acid content must then be 1 to 3% lower than calculated while the content of oleic acid is 3 to 6% lower than the true content of monoenoic acids.

As far as the differences between winter fat and spring and summer fat are concerned, Hilditch (25, 26) pointed out that this cannot be due to change in feed only. The composition of the winter feed of hay and silage did not differ from the composition of the pasture feed. Therefore the differences in the fatty acid

composition must be due to some other factors, for example the temperature or the freedom of movement.

The ingestion of oils and fats can have an influence on the composition of milkfat. Oils and fats with a high degree of unsaturation increase the amount of oleic acid in milkfat. The specific unsaturated fatty acids of the oils do not appear in the milkfat (for example linoleic and linolenic acid from linseed oil and soyabean-cake (25, 36)) or only to a small extent (erucic acid from rape oil, C_{20} and C_{22} unsaturated acids from codliver oil). Cottonseed (the oil of which contains mainly palmitic, oleic and linoleic acids) does not give a high content of these acids in the fat of buffalo milk (1). On the other hand coconut oil (Table II) and palm kernel oil, both rich in myristic and lauric acid, definitely increase the contents of these acids in milkfat (25).

Smith and Dastur (cited from 25) studied the effect of fasting on the composition of milkfat. The oleic acid increased from 30.5 to 50.1 mol %, while the butyric acid content decreased from 9.7 to 3.5 mol %. Also the content of the other lower saturated fatty acids decreased, while the stearic acid content increased. In general the milkfat secreted during fasting resembled more closely the depot fats of the cow.

The variations in the fatty acid composition due to season were investigated by Hansen and Shorland (22). They took samples at two months intervals from a creamery in a district in which more

than 85% of the cows were Jerseys. The milking season starts in July in New Zealand. The cows are the whole year on the pasture. The poorest pasture conditions occur in March. Some of their results are given in Table III. The C_4 to C_{12} fractions (lower saturated fatty acids) reacted strongly on the season as well as the iodine value. Consequently the Reichert-Meissl value and the C_{18} unsaturated fatty acids content respectively varied in the same way. The palmitic acid content was very constant. The highest iodine value was found in spring, the time with the poorest pasture conditions. The fat tended to have the same composition as the fat obtained by the fasting experiment of Smith and Dastur referred to above.

In other investigations, dealing with seasonal variations, spectrophotometric methods were used and consequently, only the amounts of unsaturated fatty acids identified according to the number of double bonds were reported.

Schaffer and Holm (43) determined the absorption of milk-fat at 232 mu and 268 mu after isomerization in ethylene-glycol-potassium hydroxide solutions and calculated the amount of dienoic and trienoic acids present. They did not correct for absorption before isomerization, nor for irrelevant absorption. They found a dienoic acid content of 2.11, 2.11 and 2.42% in pasteurized winter, spring, and summer butter respectively. The trienoic acid content was in the same order 1.29, 1.20 and 1.09%.

Matson (36) found that summer pasture butterfat contained a higher amount of conjugated dienoic acid than winter butterfat (0.1 to 3.7% and 0.6 to 1.4% respectively). There was not a clear seasonal variation in the non-conjugated fatty acids contents. The non-conjugated dienoic acid content varied from 0.8 to 2.0%, while the non-conjugated trienoic acid content varied from 0.7 to 2.0%. Therefore the seasonal variations of the total dienoic acids (conjugated plus non-conjugated) is in agreement with the result of Schaffer and Holm. Lembke and Kaufmann (34) also found an increase of the dienoic and trienoic acids in summer, compared with the winter.

The seasonal variations in the unsaturated fatty acids in New Zealand as estimated by spectrophotometric methods were reported by McDowell (37). He calculated the oleic acid content from the spectrophotometric analyses and the iodine value as suggested by Mitchell et al (38). As stated before, this does not give too reliable figures, because of the presence of other monoenoic acids with smaller molecular weights. The results are reproduced in Table IV. The variation in iodine value is in accord with the results of Hansen and Shorland (Table III). Only the oleic acid and the conjugated dienoic fatty acid contents showed a definite trend in relation to the season, positively correlated with the iodine value. The other unsaturated fatty acids varied irregularly.

Somewhat different from the results of McDowell are those

of Shorland (44). He compared the dienoic and trienoic acid contents of two samples of butterfat and found:

	Dienoic acid		Trienoic acid	
Churn date	Conjugated	Non-conjugated	Conjugated	Non-conjugated
June 28, 1948	1.31	1.27	trace	3.14
March 24, 1949	0.51	4.63	.05	2.83

The conjugated dienoic acid content for March is half as much as the content reported by McDowell, while the non-conjugated dienoic and trienoic values are unusually high. This may be due to individual variations.

Smith and Jack (47) studied seasonal variations in California. They found a seasonal variation in the conjugated dienoic acid content only, it being the highest in July and August. The content of the other acids varied considerably, but not regularly. This is in agreement with the results of the other investigators already mentioned. The average values for conjugated dienoic, trienoic and tetraenoic acids were 0.89, 0.02 and 0.03%, while those for the non-conjugated acids were 1.45, 0.83 and 0.35%, respectively.

It must be kept in mind that variations due to stage of lactation and the seasonal variations occur together and are hard to distinguish. Generally speaking most cows are in early or middle

lactation period in the months of July and August. This may account partly for the differences between winter and summer fat.

The investigations of Holland et al. (29) give some indication of the differences between the fatty acid composition of milkfat of different breeds and the variations due to stage of lactation. They found that Jersey milkfat contained smaller amounts of the low molecular and high molecular fatty acids, but more of the medium molecular weight (C_8 to C_{12}) saturated fatty acids and more of the unsaturated fatty acids than Holstein cows did. During the stage of lactation there is a marked increase in the content of higher saturated fatty acids.

Also noteworthy in this respect are the investigations of Bartley et al. (10) on the iodine value and thiocyanogen value and of Taha and Kalib (48) on the iodine value of the milkfat during the lactation period.

Bartley and coworkers (10) found that the milkfat from cows kept in the barn had a high iodine value in the first month, which dropped slowly to a minimum in the fourth and fifth month. Only poor milk producers were able to maintain a high iodine value. The linoleic acid content, as calculated from the thiocyanogen values did not vary much. If the cows were transfered to the pasture in the early lactation period, the iodine value did not change, apparently because it was already high. If transfered in the middle or late lactation period however, the iodine value increased.

Taha and Katib (48) studied the variations of the Reichert-Meissl value and of the iodine value at two week intervals during the whole lactation period. There are large variations in sample to sample determinations of both values. The first sample after calving had a low Reichert-Meissl value and a high iodine value. Over the whole lactation period there was a tendency of the Reichert-Meissl value to increase, while at the same time the iodine value tended to decrease. The Polenske value did not change much.

3. The composition of colostrumfat.

Detailed analyses of cow colostrum milkfat were reported by Baldwin and Longenecker (9) and Anantakrishnan et al. (43).

The former investigators mixed the milk of the first four days after calving and investigated the fat according to the methyl-ester fractionating technique, using spectrophotometric methods for the poly-unsaturated fatty acids. The cows were fed grass-clover hay, cornsilage and grain during two months before calving. Their results are reproduced in Table V, together with the results of Anantakrishnan et al. (43). The latter investigators took the milk of 6 cows of 4 different Indian breeds. They mixed morning and evening milk and investigated the milkfat from individual cows for physical properties. For the detailed fatty acid composition the milkfat of the 6 cows of the same days were mixed. The cows were fed on a diet of wheatbran, groundnutcake, grainhush and grain before calving. The grainhush was dropped a few weeks before calving,

while crude cane sugar and green grass was added a few days after calving. The physical properties of all the individual milkfats showed exactly the same variations with days after calving. Therefore the values of the mixed samples only are reported in Table V.

The results of Baldwin and Longenecker and Anantakrishnan et al. agree qualitatively. Compared with normal milkfat (Table I) there are large differences in composition. Most remarkable are the low butyric acid and caproic acid contents and the larger amounts of palmitic acid, stearic acid, oleic acid and poly-unsaturated fatty acids present. Correlated with these contents are a low saponification value, a low Reichert-Meissl value, a low Polenske value and a high iodine value. The differences with normal milk disappeared in 4 or 5 days. In the results of Anantakrishnan et al. the palmitic acid, stearic acid and oleic acid contents decrease from the first to the tenth day. This decrease is balanced by the fatty acids with less than 18 carbon atoms, the contents of nearly all of which increase.

In general early colostrumfat shows similarities to milkfat obtained after fasting. Both tend to become similar to the cow depotfat. However while under fasting conditions, it may be supposed that part of the depotfat is used for the production of milkfat, this is not so evident for the colostrumfat, because the cow has its normal diet. One hypothesis has been put forward that

oleic acid is dissimilated in metabolic processes and that the intermediates, being lower unsaturated fatty acids (C_{10} to C_{16}) and especially the lower saturated fatty acids (C_4 to C_8) are taken up in the glyceride structures and so protected from any further breakdown. Because there is a low fat production immediately after calving and also during fasting, oleic acid is broken down more completely; this means there are fewer lower acids present to go into the glyceride structure. However nothing is proven in this respect. This is referred to again in the "Discussion".

Anantakrishnan and coworkers (4) also studied the colostrum-fat of buffaloes, kept under similar feeding conditions as the cows, as mentioned before. Buffalo colostrumfat showed the same characteristics as cow colostrumfat, except for the palmitic acid content, which increased sharply the first days after calving. This is balanced by a smaller increase in the lower saturated acids content and a large decrease in the stearic acid content. The oleic acid content also dropped appreciably.

Baldwin and Longenecker (8) investigated human milkfat. It differed from cow milkfat in having a very low butyric acid content. The milkfat from the first days after birth did not change much from normal milkfat. The stearic acid content was a little higher, the myristic and lauric acid contents were a little lower than in mature milkfat. Of the unsaturated fatty acids only the tetraenoic acid was present in large amounts. The oleic acid content

did not change.

4. Spectrophotometric analysis of fatty acids.

The quantitative determination of poly-unsaturated fatty acids by spectroscopic methods was developed only recently and was put forward for the first time by Mitchell et al. in 1943 (38).

It was well known (17) that the conjugated double bonds in fatty acids have strong absorption in the ultra-violet region, depending on the number of double bonds. However, most of the naturally occurring poly-unsaturated fatty acids are non-conjugated fatty acids, with no specific absorption bands. Therefore it is necessary to convert these acids quantitatively to conjugated fatty acids.

Moore (39) was the first investigator who discovered that the absorption of plantfats at 232 mu and 270 mu increased remarkably if heated with alkali. Fats that had already a high absorption at these wavelengths did not get a much higher one. This proved that conjugated fatty acids with two and three double bonds were formed from other fatty acids during this treatment, which were evidently the corresponding non-conjugated fatty acids.

Mitchell et al. (38) used this as a basis for a quantitative method for non-conjugated fatty acids. As standards they used linoleic and linolenic acid, obtained from natural sources by the bromination-debromination technique. The ethyl esters of these

acids were heated in a ethylene glycol-potassium hydroxide solution in an oilbath at 180°C. The ethylene glycol solution was 1.3 N with respect to potassium hydroxide. The effect of heating time on the conversion of these non-conjugated fatty acid esters to their conjugated isomers was studied first. For instance the absorption of linoleic acid at 234 mu rapidly increased in the first 20 minutes and then leveled off to a nearly constant value. The absorption of linolenic acid at 234 mu and 268 mu increased rapidly with the heating time to a maximum, which was reached at 15 minutes, after which it decreased slightly. They chose therefore as a standard time 25 minutes. The absorption coefficients produced under these circumstances are given in Table VI. The linolenic acid content can be calculated from the absorption at 268 mu, if no other acids that absorb at this wavelength are present. The linoleic acid content can be computed from the absorption at 234 mu, after this has been corrected for the absorption of the linolenic acid present.

With the same method Beadly and Kraybill (11) measured the specific absorption of a non-conjugated tetraenoic acid, arachidonic acid. Their results can also be found in Table VI.

Baldwin and Daubert (7) checked the method for synthetic glycerides and found it satisfactory. It is advisable to be very careful in handling the fat for spectrophotometric determinations, as their statement shows that "our experience has indicated that manipulation of glycerides containing these unsaturated acids in the

presence of air tends to increase the conjugated double bond material".

The method was retested and improved by Brice et al. (14, 16). First of all they took into consideration the presence of conjugated fatty acids in the original material. They made a correction as well for irrelevant absorption due to the presence of other absorbing material (background absorption). A correction was also made for the absorption of the carbonyl groups present.

The isomerization solution of ethylene glycol-potassium hydroxide was abandoned by them, mainly because of the irregular blank absorption due to oxygen influence. They used instead an 11.0% potassium hydroxide glycerol solution. The influence of the heating time was studied with similar results as those of Mitchell et al. The optimum time was 45 minutes. However, because they wanted to use the results of Beadly and Kraybill (11) for arachidonic acid, they chose 30 minutes which had about the same effect as 25 minutes heating in ethylene glycol-potassium hydroxide. Their results are also reproduced in Table VI. From their results they derived formulae for the calculation of the amounts of poly-unsaturated fatty acids in fatty materials. As to the value of the method they stated: "The accuracy of the method is probably not as high as the reproducibility. Factors contributing to the uncertainty of the results include imperfections in the corrections for interfering constituents, incomplete identification

of impurities in the standards used and the possible presence in some samples of isomers having conjugation rates different from those of the standards. It is conservatively estimated that the errors of the method are within 10% of the quantity present, when that quantity is near 10%; ±25% when that quantity is near 1%; and that the results are at least correct in order of magnitude, when the quantity present is 1% or less".

O'Connor et al. (40) modified the ethylene glycol potassium hydroxide technique by blanketing the reagent with nitrogen during the preparation and isomerization. This resulted in a higher, more reproducible transparancy of the medium. This modified method was accepted by the spectroscopy committee of the American Oil Chemists Society as a recommended method (5). However blanketing should not make much difference. The isomerization solution is prepared and used near the boiling point of the liquid so that it is always blanketed by its own vapor. Therefore Brice and coworkers (15) could report later that there was not much real difference with or without the use of nitrogen.

Recently the results of a thorough investigation of spectrophotometric methods was published by Brice et al. (15). Certain discrepancies had developed when using the spectrophotometric method on certain oils and fats. Strong evidence existed that this was partly due to the occurrence of geometric isomeric fatty acids

that do not have identical isomerization rates and therefore gave rise to unequal absorption after isomerization. The fatty acids isolated and purified by the bromination-debromination technique were especially suspect in this respect, compared with the natural fatty acids, because these chemical methods of isolation readily change the geometrical configuration.

Therefore their main objective was to standardize the method with natural fatty acids. These fatty acids were isolated from natural sources by physical procedures such as chromatography and fractional crystallization.

In addition to a comparison of both types of acids, comparisons were made between different methods of isomerization:

a. The ethylene glycol-potassium hydroxide method for 25 and 45 minutes with or without blanketing with nitrogen;

b. The glycerol-potassium hydroxide method for 30 and 45 minutes.

The best method proved to be the glycerol-potassium hydroxide-45 minute one followed by the ethylene glycol-potassium hydroxide-45 minute method. However both gave satisfactory results if standardized procedure and calculations were adhered to rigidly. Some of their results are given in Tables VI and VII.

Herb and Riemenschneider (24) studied the effect of isomerization procedures on the absorption of poly-unsaturated fatty acids up to and including 5 double bonds. They found that an

ethylene glycol, 21.0% potassium hydroxide-nitrogen-15 minute method gives a more accurate estimate of the more unsaturated fatty acids, due to increased absorption (2 to 3 times as high). Some of their results are also included in Table VI.

From the results in Table VI it can be concluded that a difference in absorption after isomerization exists between natural fatty acids and fatty acids, isolated with the bromination-debromination techniques. Hence it is advisable to standardize the method with natural fatty acids.

The results in Table VI indicate as well the influence of the alkali concentration and isomerization time on absorption.

METHODS.

The milk samples were obtained from cows of the purebred Holstein herd of the University of Manitoba during the period June to December 1954.

Two quart samples were taken from every milking after calving, usually up to and including the 10th milking. The fat content of the milk was determined and the samples were placed in the cooler overnight. The milk was skimmed as completely as possible and the resulting cream churned in glass bottles. The butter was melted and the fat filtered at 45°C. One or more samples were taken a few weeks after calving for comparison. This sample was a mixed sample from evening and morning milk.

The fat content was estimated by the official Babcock test (2).

The Reichert-Meissl, Polenske, saponification and iodine value determinations were performed as described in the official methods of the A.O.A.C. (6). The poly-unsaturated fatty acid contents were estimated according to the original Brice et al. method (14), using the isomerization technique of Mitchell et al. (38). This method has been used in this laboratory so the results might be comparable with those of McDowell (37), who used the same procedure after finding the glycerol-potassium hydroxide not practical in handling. In the light of the recent investigation of Brice and coworkers (15) the method itself is useful and satisfactory. The

formulae used for the calculations of the concentrations are also the same as given in the original paper (14). These were in use in this laboratory at the time the project started. These formulae are similar to the new ones, based on natural fatty acids (15). A comparison of these formulae in Table VII with those given below indicates that the results will not show large differences. To give some idea of the differences involved, the results for cows no. 7 and 8 are calculated by both sets of formulae (Table XV and XVI).

The absorption of the conjugated fatty acids was measured as follows:

0.1 gram fat was dissolved in 200 ml. petroleum ether and spectrophotometric readings made at 232, 262, 268, 274, 310, 316 and 322 mu. The specific absorption coefficients were calculated for each wavelength:

specific absorption coefficient $K_{232} = \frac{D_{232}}{Cxl}$ etc, wherein

D_{232} = optical density.

C = concentration in grams per liter.

l = inside width of the absorption cell.

The isomerization was carried out as described by Mitchell and coworkers (38). The isomerization solution was prepared by dissolving 7.5 gram high grade potassium hydroxide in 100 ml. ethylene glycol. The solution was heated to 180°C. and kept at this

temperature for 30 seconds and cooled. The isomerization procedure as directed by Mitchell et al. is:

"Weigh out accurately about 0.1 gram fat or fatty acids into a small vial of the type used for iodine number determinations. Add 10 ml. of the alkaline glycol reagent with a pipet to a 15 x 2.5 (6 x 1 inch) test tube in an oilbath at 180°C. Cover the tube with a loosely fitting glass stop. The tubes should always be immersed in the bath to a constant depth. When the temperature of the reagent in the test tube has reached 180°C. drop in the vial containing the fat sample. Swirl the tube three times at 1 minute intervals to mix the fat with the glycol solution. At the end of 25 minutes remove the tube and cool rapidly under the tap. Transfer the contents of the tube quantitatively to a 250 ml. volumetric flask, using ethanol to wash out the tube and dilute to volume with 99% alcohol.

"Allow the samples to stand in a refrigerator for 5 or 6 hours or overnight. At the end of this time, material removed from the glass by the hot alkaline solution will have been precipitated. Bring the solution in the volumetric flask to room temperature and filter a portion of the solution. Make proper dilutions for absorption measurements using 99% alcohol.

"It is necessary to carry a blank solution, consisting of alkaline glycol, throughout the whole of the procedure, including dilutions, for use in the solvent cell".

Spectrophotometric measurements were made on the undiluted solutions at 310, 316 and 322 mu. The solutions were diluted 5 times for measurements at 232, 262, 268 and 274 mu. For all wavelengths the specific absorption coefficients were calculated (K'_{232} etc.), and corrected for irrelevant absorption (K_2 etc.).

For conjugated fatty acids the following formulae were used (C_2 etc. being the contents in % by weight):

$$K_2 = K_{232} - 0.07; \qquad C_2 = \frac{100\ K_2}{119};$$

$$K_3 = 2.8\ (K_{268} - \tfrac{1}{2}\ (K_{262} + K_{274})); \qquad C_3 = \frac{100\ K_3}{214};$$

$$K_4 = 2.5\ (K_{316} - \tfrac{1}{2}\ (K_{310} + K_{322})); \qquad C_4 = \frac{100\ K_4}{220}.$$

The non-conjugated fatty acids were calculated as follows (C'_2 being the contents in % by weight):

$$K'_2 = K'_{232} - K_{232}$$

$$K'_3 = 4.1\ (K'_{268} - \tfrac{1}{2}\ (K'_{262} + K'_{274})) - K_3$$

$$K'_4 = 2.5\ (K'_{316} - \tfrac{1}{2}\ (K'_{310} + K'_{322})) - K_4$$

$$C'_2 = 1.125\ K'_2 - 1.27\ K'_3 + 0.04\ K'_4$$

$$C'_3 = 1.87\ K'_3 - 4.43\ K'_4$$

$$C'_4 = 4.43\ K'_4$$

The content of non-conjugated pentaenoic acid was approximated from measurements at 342, 348 and 354 mu, using data from Herb and Riemenschneider (24) for isomerization under similar circumstances. Results are only available for cows 5, 6, 7 and 8. The absorption at 232, 268 and 316 was not corrected for the presence of pentaenoic acid because of lack of exact data. The amounts of non-conjugated dienoic, trienoic and tetraenoic acids therefore are smaller than calculated, especially the tetraenoic, which may be up to 50% too high.

The amounts of acids are given as % of the whole fat. The amounts of the other unsaturated fatty acids, chiefly oleic, were calculated from the iodine value of the fat and those of the fatty acids and reported as "monoenoic" acid. The real amounts of monoenoic acids are lower, due to the presence of lower unsaturated fatty acids, with consequently a higher iodine value. As stated in the literature review, the amount of monoenoic acid is 1 to 3% lower than the value, reported as "monoenoic" acid, while the oleic acid content is 3 to 7% lower than the true monoenoic acid content.

The following formula can be used

$$\% \text{ "monoenoic" acids} = \frac{\text{I.V.fat} - (C_2 \not C'_2)181.03 - (C_3 \not C'_3)273.51 - (C_4 \not C'_4)333.50}{89.87} \times 100$$

RESULTS.

Some particulars of the eight cows, the colostrumfat of which was investigated, are given in Table VIII. The cows were not selected for any special characteristics, but were chosen when they calved at a convenient time. The eight cows fall into two groups, namely the cows that calved during the summer months and the cows that calved during the winter months. Both groups include a heifer (numbers 4 and 7). In summer the cows were usually taken into the barn a few days before calving. Suckling was limited as far as possible.

The results of the analyses are given in Tables IX to XVI inclusive. The same results are reproduced in Graphs I to XVI inclusive. Table XVII and Graphs XVII and XVIII contain the average values for all the cows, as well as for both seasonal groups; these average values are compared at the bottom of the Tables with average values of the milk of the whole herd for the months November, December and January and June, July and August.

The analyses of variance of the first 10 milkings are reported in Tables XIX to XXVII inclusive. In the cases in which the F test for milkings was significant, regression coefficients were calculated. The regression formulae are also given in these Tables.

DISCUSSION.

Obviously the main point of interest is the answer to the question "Is there any general trend of changing composition in colostrumfat after calving?".

It is anticipated that there will be differences between individual cows as well as between summer feeding and winter feeding. Tables XIX to XXVI show that this is really the case for nearly each constituent and constant determined. Too much significance however must not be attached to the seasonal influence. Although the cows were selected at random in winter as well as in summer, as they calved at a convenient time, the number of cows in each group is in itself too small to represent an unbiased estimate of the seasonal population. However the fact that the averages for the summer calving group and for the winter calving group in general show differences similar to normal seasonal variations(Tables XVII and XVIII) indicates that the differences are at least partly seasonal.

Another point of interest would be the differences between heifers and older cows. The number of cows and heifers however was too small to permit statistical work in this respect. Comparing the results of the heifers (numbers 4 and 7) with the results of the other cows reveals no marked differences.

Consequently we can restrict ourselves in this discussion to the variations due to the number of milkings after calving.

Fortunately we are able to compare our results with the results of a similar unpublished investigation on the milk of the whole herd. These, for the last year that they were obtained, are reproduced in Table XVIII.

In the first place there seem to be some constituents and constants of colostrum fat that are not dependent on the number of milkings after calving. These are the fat content of the colostrum (which is in accordance with the literature), the contents of the conjugated fatty acids, the non-conjugated trienoic acid and the Polenske value. The conjugated dienoic acid content tends to increase slightly after calving, although in summer this increase occurs only after a minimum at about the fifth milking (see Table XVII). The Polenske value is very low and tends to decrease after calving. It points to a low content of volatile water-insoluble fatty acids during an extended period, when the colostrumfat is already normal again in many respects.

The constants and constituents, that have a different value and concentration in colostrumfat are the iodine value (and therefore also "monoenoic" and total unsaturated fatty acids), the saponification value, the Reichert-Meissl value and the contents of non-conjugated dienoic and tetraenoic acids.

During the first ten milkings, the Reichert-Meissl value and the saponification value show a quadratic regression with the number of milkings, the other values and concentrations a linear

regression.

As all the graphs show, the Reichert-Meissl values and the saponification values are closely correlated, except in such cases where there is an unusually large change in the total unsaturated fatty acids content, while at the same time the Reichert-Meissl value does not change (of cow 5, milking 2 and 9). Usually the Reichert-Meissl value decreases when the total unsaturated fatty acids content increases (of cow 1, milking 10; 3, milking 49/50; 4, milking 10; 6, milking 8, and 7, milking 9).

The Reichert-Meissl values increase up to as much as 100% or more during the first ten milkings, independently of how the iodine value changes. The increases in the Reichert-Meissl values are more regular and larger for the winter cows, than for the summer cows.

The saponification value varies with the amounts of fatty acids of different chain length present. Usually it shows a trend similar to that of the Reichert-Meissl value, which is a measure of short chain fatty acid content. The high saponification value for cow 1, milking 5 to 7, must be due to a large amount of non-volatile short chain fatty acids, while on the other hand the slight decrease in saponification value for cow 4, milking 5 to 10 must come from a large amount of long chain saturated fatty acids as palmitic and stearic, because the Reichert-Meissl value is increasing and the total unsaturated fatty acids content is decreasing.

The saponification values for cows 1, 2, 4, 7 and 8 are below the herd values, while the Reichert-Meissl values are well above the herd values for the 8th, 9th and 10th milking. This means that the medium molecular weight fatty acids are present only in relatively small amounts.

For the majority of the cows the iodine value increases during the first days after calving. The summer cows, except 4, especially show regular increases. Table XX shows that there is a significant linear regression for the average values, as can also be seen from Table XVII and Graph XVIII. The iodine value for most cows seems to approach a maximum value at the end of the 5th milking. In winter as well as in summer, the averages are above the herd values. However the individual variations are large within each group. They seem to be more important than the influence of season or feed.

The increase in the iodine values during the first 5 days after calving was not found by Anantakrishnan et al. (3) whose results have been reproduced in Table V. He found a decrease for cows as well as for buffaloes (4). Our results agree with those of Taha et al. (48).

The non-conjugated dienoic acid content of colostrumfat is much higher than normal. It decreases slowly, but in most cases the normal content was not yet reached at the 10th milking. The concentration varies from milking to milking. The composition of

the feed may have some influence on these variations.

The most remarkable difference between colostrumfat and normal milkfat is found in the content of non-conjugated tetraenoic fatty acids. Without any exception and without much interference from normal daily variations, the content of non-conjugated tetraenoic fatty acids decreases from the first to the 10th milking. The initial value is up to 5 times the normal herd average.

The same holds for the content of non-conjugated pentaenoic acids (Tables XIII to XVI, Graphs IX, XI, XIII, and XV). The pentaenoic acid content is almost exactly 50% of the content of tetraenoic fatty acids.

Except for the iodine values, and consequently also for the "monoenoic" and total unsaturated fatty acid content, our results are in general in agreement with those of Baldwin and Longenecker (9) and Anantakrishnan et al. (3), insofar as they are comparable.

On the basis of these results it would be expected that, due to the seasonal differences in calving frequencies, the seasonal variation in the composition of milkfat would be correlated with the abnormal composition of colostrumfat. However a comparison with the results in Table XVIII does not reveal such a relationship. The highest calving frequency is in the spring. The highest iodine values and conjugated dienoic acid contents occur in late summer, concurrent with a low Reichert-Meissl value and a low

saponification value. The non-conjugated dienoic and tetraenoic acids do not show a definite seasonal variation. It must be concluded, therefore, that seasonal variations in the composition of milkfat are not induced or dominantly influenced by seasonal variations in the amount of milkfat from freshly calved cows. Of course the colostrum of at least the first 3 or 4 milkings is not mixed in with the normal milk.

The second question of interest is the relation between the abnormal composition of colostrumfat and the physiological process of fat synthesis. Not much is known about the synthesis of fat and fatty acids in the udder. Smith (46) gives a review of recent investigations on the synthesis of fatty acids in the udder. The short chain fatty acids are most probably built up from acetate. On the other hand it has been established that part of or all of the long chain fatty acids are entering into the udder from the bloodstream in the form of mono- and diglycerides (19). However, other investigators (especially Hilditch and coworkers) assume that the short chain fatty acids originate from oleic acid, which enters the udder from the blood in a glyceride structure. Their assumption is based on the results of the study of milkfat composition under different circumstances.

The remarks to be made are based on the assumption that the lower fatty acids are synthesized in the udder while the higher fatty acids at least partly come from the blood glycerides.

The low content of short chain fatty acids in colostrum-fat can be explained on the basis of low synthesizing capacity of the udder, when the milk secretion starts again. It is a few days before the production of lower fatty acids reaches its maximum. A small production of fatty acids in the udder makes it necessary that more fatty acids are "imported" via the bloodstream. However this increased "import" of fatty acids itself does not account for the fact that the relative proportions of the different types of long chain fatty acids are also changing. Apparently the starting anew of the milk secretion changed the composition of the supply of fatty acids, that goes in into the udder. Which part of the body controls this supply and where these fatty acids are coming from are interesting questions not yet answered.

Another point of interest is the relation between the colostrumfat composition and the needs of the newborn calf. Poly-unsaturated fatty acids are part of important compounds in the body, for instance phosphatides and are also supposed, and partly proven, to be necessary in the food for good normal growth of animals. In these respects it may be important for the calf to have a good supply of these acids when it has only a small synthesizing capacity for them.

The nutritional importance of the low content of volatile fatty acids is hard to visualize; the special nutritional value of these acids is unknown or doubtful.

SUMMARY.

It was found that colostrumfat differed from normal milkfat in several respects. Colostrumfat from the first milkings was characterized by a higher degree of unsaturation, a low saponification value, a low Reichert-Meissl value and a low Polenske value. The conjugated fatty acids occur in normal amounts, while the contents of the non-conjugated dienoic, tetraenoic and pentaenoic fatty acids are unusually high. The saponification value and the Reichert-Meissl value return to normal levels very rapidly, while the iodine value, the Polenske value and the contents of the non-conjugated fatty acids are not yet normal on the 10th milking after calving with most cows.

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APPENDIX.

TABLE I.

The Fatty Acid Composition of Milkfat.

Sample No.	1	3	4	5	6
Reichert-Meissl Value			26.1	27.4	26.1
Polenske Value			1.85	1.78	1.40
Iodine Value			37.5	42.9	40.5
Acids:			Weight %		
Butyric	3.52	3.0	3.6	3.7	3.5
Caproic	1.40	1.4	2.0	1.7	1.9
Caprylic	1.68	1.5	0.5	1.0	0.7
Capric	2.67	2.7	2.3	1.9	2.1
Lauric	4.54	3.7	2.5	2.8	0.9
Myristic	14.65	12.1	11.1	8.1	7.9
Palmitic	30.05	25.3	29.0	25.9	25.8
Stearic	10.45	9.2	9.2	11.2	12.7
As Arachidic	1.68	1.3	2.4	1.2	1.5
Total saturated	70.64	60.2	61.5	57.5	58.0
Decenoic	0.25	0.3	0.1	0.1	0.1
Dodecenoic	0.15	0.4	0.1	0.2	0.2
Tetradecenoic	1.48	1.6	0.9	0.6	0.6
Hexadecenoic	5.69	4.0	4.6	3.4	2.4
Oleic	18.69	29.6	26.7	32.8	34.0
As Octadecadienoic	--	3.6	3.6	3.7	3.7
As C_{20}-C_{22} Unsat.	3.10	0.3	1.4	1.7	1.0
Total unsat.	29.36	39.8	38.5	42.5	42.0

TABLE I. (Cont.)

Sample No.	2	3	4	5	6
Reichert-Meissl Value					
Polenske Value					
Iodine Value					
Acids:		Mol %			
Butyric	9.2	8.1	9.5	9.9	9.5
Caproic	2.8	2.8	4.1	3.5	4.0
Caprylic	2.7	2.5	0.8	1.6	1.1
Capric	3.5	3.7	3.2	2.6	2.9
Lauric	5.2	4.4	2.9	3.4	2.3
Myristic	14.8	12.5	11.5	8.5	8.2
Palmitic	27.2	23.2	26.7	24.0	24.1
Stearic	8.5	7.6	7.6	9.4	10.7
As Arachidic	1.2	1.0	1.8	0.9	1.1
Total saturated	75.1	65.4	68.1	63.8	63.9
Decenoic	0.3	0.4	0.1	0.1	0.1
Dodecenoic	0.2	0.9	0.1	0.2	0.2
Tetradecenoic	1.5	1.7	0.9	0.6	0.7
Hexadecenoic	5.2	3.7	4.3	3.2	2.3
Oleic	15.3	24.8	22.4	27.7	28.8
As Octadecadienoic	0.7	2.9	3.1	3.1	3.2
As C_{20}-C_{22} Unsat.	1.7	0.2	1.0	1.3	0.8
Total unsat.	24.9	34.6	31.9	36.2	36.1

Sample Description:

1. Origin unknown (30);
2. Origin unknown (31);
3. Winterfat, normal diet (27);
4. Shorthorn cows, winterfeed: silage (grass and clover) (27);
5. Shorthorn cows, early summer pasture (27);
6. Ayrshire cows, late summer pasture (27).

TABLE II.

The Composition of 8 Butterfat Samples (28).

Sample	Iodine Value	Total Unsat.	C_4-C_{12} Acids	C_{14}/C_{16} Acids	C_{18}-C_{22} Acids
Barnfed, coconut cake	31.6	27.6	27.2	41.3	31.5
Spring pasture	34.5	29.8	23.7	36.5	39.8
Barnfed, soyabean cake	34.8	30.0	28.0	34.4	37.6
Indian cow ghee (pasture)	36.0	32.1	24.7	37.7	37.6
New Zealand market Sample I	38.0	32.7	20.7	35.9	43.4
New Zealand market Sample II	39.4	33.9	21.0	37.2	41.8
Pasture and barnfed	41.3	37.0	21.6	34.3	44.1
Spring pasture	41.6	38.1	21.3	35.2	43.5

(Contents in mol %).

TABLE III.

Seasonal Variations in the Composition of New Zealand Milkfat (22).

Sample Date	Iodine Value	Reichert-M. Value	Sapon. Value	C_4-C_{12} Acids	C_{18} Unsat. Acids	Total Sat.
July 28, 1948	39.9	31.1	226.4	22.2	29.5	65.9
Sept 15, 1947	38.4	31.7	229.6	24.4	28.1	67.6
Nov. 18, 1948	33.6	32.0	233.3	26.1	23.4	72.1
Jan. 28, 1948	36.8	30.1	229.9	24.4	25.6	70.1
April 6, 1948	39.9	27.3	225.3	20.7	29.2	65.7
May 18, 1948	40.8	25.2	225.1	19.8	29.8	65.3
March 3, 1949				22.6	27.0	67.8

(Contents in mol %).

TABLE IV.

Average Monthly Composition of New Zealand Butterfat (37).

Sample Date	Iodine Value	Oleic Acid	Dienoic		Trienoic		Tetraenoic	
			Conjug	Non-Conjug.	Conjug.	Non-Conjug.	Conjug.	Non-Conjug.
Oct. 1949	36.7	33.8	1.4	0.3	Trace	0.9	Nil	0.3
Nov. 1949	33.5	30.5	1.2	0.4	"	0.8	"	0.3
Dec. 1949	32.1	29.3	0.9	0.5	"	0.8	"	0.4
Jan. 1950	33.0	30.1	0.8	0.6	"	0.9	"	0.3
Feb. 1950	34.2	32.7	0.8	0.3	"	0.7	"	0.3
March 1950	35.9	33.4	1.1	0.7	"	0.6	"	0.4
April 1950	37.9	35.8	1.3	0.2	"	0.7	"	0.3

(Contents in weight %).

TABLE V.

The Composition of Cow Colostrumfat.

Reference No.	(9)	(3)	(3)	(3)	(3)	(3)	(3)	(3)
Sample		Day 1	Day 2	Day 3	Day 4	Day 5	Day 10	Day 15
Iodine Value		39.79	35.30	33.51	32.06	31.56	31.60	31.82
Reichert-Meissl Value		14.92	22.18	24.27	25.75	27.01	30.56	29.72
Polenske Value		1.10	1.40	1.70	1.95	2.04	1.96	1.98
Sapon. Value		213.1	220.4	224.0	225.1	226.8	228.2	229.6
Melting point, °C.		38.7	34.3	34.2	33.9	33.9	33.8	--
Acids:								
Butyric	2.6	2.2	2.4	2.6	2.8	3.6	3.6	
Caproic	1.6	--	0.5	0.8	1.5	0.6	0.6	
Caprylic	0.5	0.9	1.2	1.8	2.0	1.8	1.4	
Capric	1.6	1.2	1.8	2.6	2.3	2.0	1.9	
Lauric	3.2	1.4	1.8	2.0	2.7	2.6	2.6	
Myristic	9.5	9.5	9.5	10.3	10.7	11.1	10.8	
Palmitic	31.7	29.7	32.1	30.5	29.0	30.3	29.4	
Stearic	11.8	13.7	12.5	12.0	12.6	11.6	12.9	
Higher saturated	0.6	0.6	0.7	0.9	0.8	0.7	1.2	
Total saturated	63.1	59.2	62.5	63.5	64.4	64.3	64.4	
Decenoic	0.1	0.1	0.1	0.2	0.2	0.2	0.2	
Dodecenoic	0.2	0.1	0.1	0.1	0.2	0.3	0.4	
Tetradecenoic	0.7	0.8	0.8	0.9	1.1	1.2	0.8	
Hexadecenoic	2.7	3.0	3.0	4.7	4.7	3.3	3.5	
Oleic	28.5	34.1	31.0	28.2	27.5	28.8	29.3	
Octadecadienoic	2.5	1.5	1.7	1.6	0.8	0.5	0.4	
Octadeca-trienoic	0.4	--	--	--	--	--	--	
Eicosatetraenoic	0.7	--	--	--	--	--	--	
As C_{20}-C_{22} Unsaturated	1.1	1.2	0.8	0.8	1.1	1.4	1.0	
Total Unsaturated	36.9	40.8	37.5	36.5	35.6	35.7	35.6	

(Contents in weight %).

TABLE VI.

Specific Absorption Coefficients

of Poly-Unsaturated Fatty Acids

After Alkali Isomerization.

Solvent		Ethylene Glycol					
Method:	% KOH	6.5	6.5	6.5	6.5	6.5	21.0
	Time	25'	25'	25'	45'	45'	15'
	Air or N_2	Air	Air	Air or N_2	Air or N_2	Air or N_2	N_2
Reference No.		(38)	(15)	(15)	(15)	(15)	(24)
Fatty Acid Source		Br.-Debr.	Natural	Br.-Debr.	Natural	Br.-Debr.	Natural
Acid:	Wave l. (mu)						
Linoleic	232		91.7		93.5		
	233		92.1		93.9		91.6
	234	87.1	91.5		93.4		
Linolenic	232		60.7		58.5		
	233		61.6		59.0		47.5
	234	60.0	62.2		59.8		
	268	53.7	50.7		49.3		90.5
Arachidonic	232	(11)	56.1	55.4	53.8	52.9	
	233		56.9	56.2	54.5	53.7	39.7
	234	59.3	57.8	57.1	55.5	54.4	
	268	53.4	52.8	54.4	44.8	44.6	48.2
	315		21.5	23.9	22.9	24.2	60.6
	316	22.6	20.6	22.6	22.5	22.5	
50% Eicosapentaenoic	233						41.5
	268						43.6
≠50% Docopentaenoic	315						69.7
	346						69.0

TABLE VI. (Cont.)

Solvent		Glycerol				
Method:	% KOH	11.0	11.0	11.0	11.0	11.0
	Time	30'	30'	30'	45'	45'
	Air or N_2	Air	Air	Air	Air	Air
Reference No.		(14)	(15)	(16)	(15)	(16)
Fatty Acid Source		Br.-Debr.	Natural	Br.-Debr.	Natural	Br.-Debr.
Acid:	Wave l. (mu)					
Linoleic	232	88.9	90.6	88.9	93.4	90.1
	233		91.1	89.2	93.9	90.3
	234		90.2	88.6	93.3	89.8
Linolenic	232	60.0	59.5	60.0	58.2	57.9
	233		60.2	60.5	58.6	58.5
	234		60.9	61.0	59.2	59.1
	268	53.4	49.3	53.4	48.6	51.3
Arachidonic	232	59.3	56.1	55.8	54.5	55.3
	233		56.8	56.5	55.0	56.0
	234		57.6	57.2	55.8	56.8
	268	53.4	53.4	56.3	46.8	50.3
	315		19.1	21.1	20.3	21.0
	316	22.6	18.2	19.6	19.6 (23) (N_2)	19.8
50% Eicosapentaenoic	233				49.5	
	268				34.3	
≠50% Docopentaenoic	315				25.3	
	346				13.0	

TABLE VII.

Formulae for the Calculation of the Contents

Of Poly-Unsaturated Fatty Acids

(As Suggested by Brice et al (16)

For the Ethylene Glycol-Potassium Hydroxide-25 min. Method).

$$K'_2 = K'_{232} - K_{232} ;$$

$$K'_3 = 4.05 \left[K'_{268} - \tfrac{1}{2} (K'_{262} + K'_{274}) \right] - K_3 ;$$

$$K'_4 = 2.06 \left[K'_{315} - \tfrac{1}{2} (K'_{308} + K'_{322}) \right] - K_4 ;$$

$$C'_2 = 1.086\ K'_2 - 1.319\ K'_3 + 0.37\ K'_4 ;$$

$$C'_3 = 1.972\ K'_3 - 4.84\ K'_4 ;$$

$$C'_4 = 4.65\ K'_4 .$$

TABLE VIII.

Some Particulars of the Cows

The Colostrumfat of Which Was Investigated.

Cow No.	Registered Name	Date of Calving	Date of Sample For Comparison	Feed Conditions etc.
1	Marygold	June 23, 1954	July 27/28, 1954	Pasture, 2 days before calving Wheatbran and hay. 1½ day suckling.
2	Porry	June 30, 1954	July 27/28, 1954	Pasture. During test period hay and bran 1½ day suckling.
3	Winsome Winnie	Aug. 14, 1954	Sept. 7/8, 1954	Pasture, ½ day suckling.
4	Raymondale (heifer)	Sept. 9, 1954	Sept. 27/28 until Dec. 9/10, 1954	Pasture, 3 days bran and hay. From Sept. 27 hay, feedmix and silage.
5.	Ajax Primus	Nov. 27, 1954	Dec. 9/10, 1954	Barnfed, No suckling.
6.	Tiny	Dec. 1, 1954	Dec. 9/10, 1954	Barnfed, 1 day suckling.
7.	Ajax Ulyssus (heifer)	Dec. 18, 1954	Dec. 29/30, 1954	Barnfed, 2 days suckling.
8.	Snowden Queen	Dec. 20, 1954	Dec. 29/30, 1954	Barnfed, No suckling.

TABLE IX.

Fat Constants and Unsaturated Fatty Acid Composition

Of the Colostrumfat of Cow No. 1.

Milking No.	% Fat	Iodine Value	Sapon. Value	Reichert-Meissl Value	Polenske Value	Conjugated Dienoic	Conjugated Trienoic	Non-Conjugated Tetra-enoic.	Non-Conjugated Dienoic	Non-Conjugated Trienoic	Non-Conjugated Tetra-enoic.	"Mono-enoic"	Total Unsat.
	Fat Constants					Unsaturated Fatty Acids		Weight % of Fat.					
1	-	45.51	216.6	17.4	0.6	0.54	0.01	Trace	2.61	0.70	1.39	36.96	42.21
2	4.8	46.06	215.7	19.3	0.6	0.51	0.01	Tr.	2.49	0.61	1.31	38.47	43.39
3	3.6	46.43	216.3	20.6	0.5	0.46	0.01	Tr.	2.31	0.61	0.97	40.60	44.95
4	3.4	47.28	216.3	20.4	0.5	0.46	0.01	Tr.	2.60	0.63	0.92	41.06	45.67
5	2.1	47.29	220.4	20.7	0.5	0.42	0.01	Tr.	2.42	0.50	0.72	42.65	46.72
6	4.2	47.85	220.5	21.1	0.6	0.43	0.01	Tr.	2.24	0.55	0.67	43.68	47.57
7	5.0	47.20	218.4	21.5	0.6	0.45	0.01	Tr.	2.39	0.51	0.60	42.98	46.93
8	4.7	47.69	214.3	21.5	0.6	0.52	0.02	Tr.	2.46	0.55	0.43	43.37	47.44
9	2.2	47.38	216.3	22.3	0.6	0.56	0.03	Tr.	2.74	0.47	0.40	42.90	47.14
10	3.4	47.43	215.5	22.3	0.6	0.59	0.03	Tr.	2.07	0.48	0.40	44.39	43.96
11	3.2	47.11	217.0	24.0	0.6	0.59	0.03	Tr.	2.14	0.49	0.40	43.86	47.51
12	3.8	45.34	218.9	24.6	0.6	0.61	0.03	Tr.	1.99	0.45	0.44	42.14	45.65
13	3.6	42.12	221.9	27.9	0.9	0.62	0.04	Tr.	2.23	0.49	0.42	38.27	41.97
14	2.6	41.41	221.7	27.9	1.0	0.65	0.02	Tr.	1.93	0.72	0.37	37.25	40.94
68/69	2.3	43.48	217.3	26.0	1.2	0.77	0.03	Tr.	1.72	0.51	0.32	40.55	43.90

TABLE X.

Fat Constants and Unsaturated Fatty Acid Composition

Of the Colostrumfat of Cow No. 2.

Fat Constants						Unsaturated fatty acids, Weight % of Fat.							
						Conjugated		Non-Conjugated					
Milking No.	% Fat	Iodine Value	Sapon. Value	Reichert-Meissl Value	Polenske Value	Dienoic	Trienoic	Tetra-enoic	Dienoic	Trienoic	Tetra-enoic	"Mono-enoic"	Total Unsat.
1	-	37.50	216.8	17.6	1.3	0.64	0.01	Tr.	1.87	0.45	1.13	31.06	35.17
2	5.2	38.47	217.9	21.9	1.0	0.62	0.02	Tr.	1.77	0.21	1.05	33.40	37.07
3	3.8	38.70	220.0	25.0	1.1	0.61	0.02	Tr.	1.75	0.31	0.84	34.21	37.74
4	3.9	40.17	221.2	27.1	1.1	0.61	0.02	Tr.	1.67	0.30	0.67	36.64	39.91
5	6.4	41.52	220.0	27.6	1.0	0.57	0.02	Tr.	1.77	0.27	0.57	38.49	41.69
6	5.6	42.69	217.5	26.2	0.9	0.55	0.02	Tr.	1.94	0.45	0.45	39.42	42.82
7	5.7	43.58	217.1	25.5	0.6	0.55	0.02	Tr.	1.82	0.40	0.43	40.88	44.09
8	4.7	43.20	217.0	26.2	0.6	0.52	0.02	Tr.	1.87	0.45	0.39	40.38	43.63
9	5.6	43.55	216.9	25.9	0.7	0.55	0.02	Tr.	1.95	0.42	0.33	40.86	44.13
10	5.0	43.83	216.5	24.4	0.6	0.54	0.02	Tr.	1.81	0.26	0.31	42.09	45.03
56/57	4.1	44.28	218.8	26.0	0.9	0.74	0.02	Tr.	1.49	0.45	0.26	42.39	45.36

TABLE XI.

Fat Constants and Unsaturated Fat ty Acid

Composition of the Colostrumfat of Cow No. 3.

	Fat Constants					Unsaturated Fatty Acids, Weight % of Fat.								
						Conjugated		Non Conjugated				"Mono enoic"	Total Unsat.
Milking No.	% Fat	Iodine Value	Sapon-Value	Reichert-Meissl Value	Polenske Value	Dienoic	Trienoic	Tetra-enoic	Dienoic	Trienoic	Tetra-enoic		
1	1.6	36.71	219.6	21.0	1.9	0.62	0.02	Tr.	2.36	0.64	1.01	29.16	33.80
2	1.2	35.50	220.2	--	--	0.59	0.02	Tr.	2.17	0.66	0.91	28.48	32.83
3	--	--	--	--	--	--	--	--	--	--	--	--	--
4	2.0	35.42	222.2	--	--	0.66	0.02	Tr.	2.09	0.60	0.88	28.74	32.98
5	3.2	36.75	223.5	28.8	1.4	0.71	0.02	Tr.	1.96	0.63	0.82	30.48	34.62
6	2.5	36.65	225.6	30.3	1.3	0.77	0.03	Tr.	1.80	0.69	0.77	30.55	34.61
7	4.0	37.43	225.5	31.8	1.3	0.79	0.02	Tr.	1.48	0.85	0.72	31.74	35.60
8	2.5	37.51	226.5	33.1	1.4	0.80	0.03	Tr.	1.33	0.84	0.68	32.30	35.98
9	3.9	37.82	225.6	33.3	1.4	0.81	0.03	Tr.	1.32	0.74	0.65	33.02	36.58
10	2.9	37.50	227.0	33.7	1.4	0.79	0.03	Tr.	1.54	0.69	0.64	32.50	36.18
49/50	4.4	43.30	219.0	25.0	0.9	0.65	0.02	Tr.	0.86	0.53	0.31	42.31	44.68

TABLE XII.

Fat Constants and Unsaturated Fatty Acid Composition of the Colostrumfat of Cow No. 4.

	Fat Constants			Unsaturated Fatty Acids, Weight % of Fat.										
						Conjugated		Non Conjugated				"Mono enoic"	Total Unsat.	Non-Conjug. Penta-enoic.
Milking No.	% Fat	Iodine Value	Sapon. Value	Reichert-Meissl Value	Polenske Value	Dienoic	Trienoic	Tetra-enoic	Dienoic	Trienoic	Tetra-enoic			
1	5.9	43.41	214.9	20.0	1.0	0.76	0.1	Tr.	2.15	0.63	0.99	36.77	41.31	
2	5.5	42.52	217.2	21.6	1.0	0.72	0.1	Tr.	1.91	0.38	1.02	37.08	41.11	
3	2.5	42.01	218.7	23.7	1.0	0.67	0.1	Tr.	1.91	0.46	0.92	36.69	40.66	
4	2.3	41.74	219.1	24.5	0.9	0.66	0.1	Tr.	1.87	0.42	0.87	36.75	40.59	
5	4.2	42.60	219.4	25.5	1.1	0.65	0.1	Tr.	1.90	0.47	0.88	37.53	41.44	
6	6.3	42.22	219.6	26.0	1.0	0.65	0.1	Tr.	1.77	0.32	0.86	37.91	41.51	
7	5.0	41.63	219.2	26.3	1.0	0.66	0.1	Tr.	1.53	0.42	0.78	37.69	41.09	
8	5.3	41.42	219.1	26.6	1.1	0.68	0.1	Tr.	1.47	0.34	0.69	38.09	41.29	
9	4.1	40.46	218.9	26.5	1.1	0.68	0.1	Tr.	1.30	0.39	0.55	37.78	40.70	
10	5.1	41.05	218.5	25.7	0.9	0.68	0.1	Tr.	1.20	0.46	0.56	38.37	41.28	
30/31	3.5	42.90	221.6	27.8	1.0	1.04	0.2	Tr.	1.22	0.57	0.39	37.91	42.15	0.18
48/49	3.3	39.52	224.1	27.5	1.5	0.82	0.2	Tr.	1.18	0.57	0.41	36.60	39.61	0.21
64/65	3.5	37.63	223.4	25.4	1.4	0.87	0.2	Tr.	0.99	0.56	0.35	35.05	37.84	0.16
80/81	3.3	36.86	228.7	28.8	1.7	0.74	0.2	Tr.	1.44	0.46	0.54	33.14	36.34	0.26
92/93	3.1	37.71	227.7	27.0	1.2	0.81	0.1	Tr.	0.73	0.36	0.35	36.39	38.66	0.16
122/123	-	34.69	228.0	27.8	1.4	0.71	0.2	Tr.	1.03	0.36	0.39	32.48	35.00	0.17
148/149	3.3	30.66	228.0	28.3	-	0.68	0.3	Tr.	0.81	0.41	0.34	28.52	30.79	0.16
176/177	3.5	33.76	226.6	25.3	1.3	0.88	0.3	Tr.	0.88	0.54	0.35	30.98	33.66	0.16

TABLE XIII.

Fat Constants and Unsaturated Fatty Acid Composition of the Colostrumfat of Cow No. 5.

	Fat Constants					Unsaturated Fatty Acids, Weight % of Fat.						
						Conjugated		Non-Conjugated			"Mono-enoic"	Total Unsat.	Non-Conjug. penta-enoic.
Milking No.	% Fat	Iodine Value	Sapon. Value	Reichert-Meissl Value	Polenske Value	Dienoic	Trienoic	Tetra-enoic	Dienoic	Trienoic	Tetra-enoic			
1	4.4	27.80	223.1	18.5	1.3	0.35	0.01	Tr	1.51	0.35	0.94	22.59	25.75	0.48
2	5.1	29.27	219.9	19.9	1.6	0.39	0.01	Tr	1.40	0.33	0.86	24.72	27.71	0.46
3	5.1	29.48	222.2	22.0	1.5	0.41	0.01	Tr	1.47	0.38	0.84	24.88	27.90	0.44
4	5.0	28.68	223.8	24.0	1.8	0.42	0.02	Tr	1.24	0.36	0.79	24.49	27.31	0.41
5	5.3	29.64	224.8	26.2	1.4	0.41	0.02	Tr	1.35	0.35	0.75	25.54	28.42	0.39
6	4.6	27.88	226.4	27.7	1.8	0.40	0.02	Tr	1.22	0.35	0.70	23.99	26.68	0.36
7	4.9	30.23	226.3	29.1	1.8	0.40	0.02	Tr	1.35	0.36	0.63	26.61	29.37	0.32
8	4.8	28.82	227.0	29.5	1.9	0.40	0.02	Tr	1.02	0.41	0.53	25.94	28.32	0.24
9	4.7	32.29	224.5	30.2	1.7	0.43	0.02	Tr	1.24	0.32	0.54	29.52	32.07	0.28
10	4.6	29.61	227.4	30.4	1.0	0.33	0.02	Tr	1.31	0.44	0.58	26.11	28.78	0.27
25/26	4.1	31.24	227.4	30.8	1.8	0.59	0.02	Tr	1.02	0.38	0.43	28.77	31.23	0.21

TABLE XIV.

Fat Constants and Unsaturated Fatty Acid.

Composition of the Colostrumfat of Cow No. 6.

	Fat Constants					Unsaturated Fatty Acids, Weight % of Fat.								
						Conjugated		Non-Conjugated				"Mono-enoic"	Total Unsat.	Non-Conjug. Penta-enoic
Milking No.	% Fat	Iodine Value	Sapon-Value	Reichert-Meissl Value	Polenske Value	Dienoic	Trienoic	Tetra-enoic	Dienoic	Trienoic	Tetra-enoic			
1	5.8	29.78	217.6	16.7	1.2	0.35	0.01	tr	1.92	0.42	0.97	23.68	27.34	0.48
2	6.1	30.37	217.5	18.1	1.1	0.35	0.01	tr	1.87	0.42	0.92	24.62	28.19	0.47
3	5.3	31.83	219.6	21.2	1.2	0.39	0.01	tr	1.67	0.45	0.84	26.85	30.16	0.41
4	5.8	33.13	220.9	24.6	1.1	0.42	0.01	tr	1.65	0.47	0.77	28.39	31.71	0.38
5	5.4	33.89	223.2	27.9	1.2	0.43	0.01	tr	1.69	0.43	0.73	29.40	32.69	0.35
6	6.2	34.38	223.6	29.5	1.2	0.45	0.02	tr	1.71	0.47	0.70	29.83	33.18	0.35
7	5.0	34.12	223.9	30.8	1.1	0.47	0.01	tr	1.60	0.43	0.63	30.12	33.26	0.29
8	5.9	35.21	223.9	30.2	0.9	0.48	0.01	tr	1.72	0.48	0.52	31.35	34.57	0.27
9	4.3	34.13	225.1	32.0	1.1	0.47	0.01	tr	1.82	0.49	0.53	29.85	33.18	0.25
10	5.4	35.39	224.5	31.0	0.9	0.50	0.01	tr	1.77	0.56	0.55	31.03	34.42	0.27
18/19	4.3	36.17	222.8	29.8	0.8	0.53	0.02	tr	1.41	0.42	0.43	33.39	36.20	0.17

TABLE XVI.

Fat Constants and Unsaturated Fatty Acid Composition of the Colostrumfat of Cow No. 8.

Milking No.	Fat Constants: % Fat	Iodine Value	Sapon. Value	Reichert-M. Value	Polenske Value	Unsaturated Fatty Acids, Weight % of Fat. Conjugated: Dienoic	Trienoic	Tetraenoic	Non-Conjugated: Dienoic (14)	Dienoic (16)	Trienoic (14)	Trienoic (16)	Tetraenoic (14)	Tetraenoic (16)	"Monoenoic"	Total Unsat.	Non-Conjug. Pentaenoic
1	5.2	33.90	215.6	17.2	1.4	0.43	0.01	tr	2.14	2.08	0.30	0.52	1.48	1.28	26.11	30.47	0.71
2	5.0	35.33	218.1	19.3	1.2	0.43	0.01	tr	2.16	2.10	0.27	0.50	1.53	1.32	27.58	31.98	0.74
3	4.0	35.18	221.1	24.0	1.4	0.44	0.01	tr	1.98	1.92	0.32	0.50	1.18	1.02	28.92	32.84	0.59
4	-	36.01	221.9	26.4	1.3	0.49	0.01	tr	2.04	1.99	0.30	0.46	1.06	0.92	30.09	33.99	0.54
5	2.7	34.98	225.0	28.6	1.4	0.51	0.01	tr	1.94	1.88	0.34	0.49	1.00	0.87	29.16	32.96	0.54
6	4.1	36.69	224.6	29.6	1.3	0.54	0.01	tr	1.86	1.80	0.34	0.49	0.93	0.80	31.47	35.16	0.46
7	3.8	37.59	222.9	30.6	0.9	0.56	0.01	tr	1.79	1.73	0.36	0.39	0.81	0.79	32.98	36.51	0.41
8	4.2	38.66	220.6	28.8	0.9	0.57	0.01	tr	1.76	1.69	0.37	0.47	0.65	0.56	34.79	38.14	0.32
9	3.7	38.37	220.3	29.2	0.7	0.58	0.01	tr	1.74	1.68	0.35	0.45	0.57	0.49	34.79	38.05	0.30
10	-	39.27	219.5	28.1	0.7	0.57	0.01	tr	1.68	1.61	0.47	0.56	0.50	0.43	35.87	39.09	0.25
20/21	-	35.33	226.1	32.7	1.3	0.60	0.02	tr	1.40	1.34	0.38	0.46	0.42	0.36	32.55	35.36	0.20

TABLE XVII.

Average Values for the Fat Constants and

Unsaturated Fatty Acid Contents of Colostrumfat.

	Fat, %.			Iodine Value			Sapon. Value		
Milking No.	Summer Cows	Winter Cows	Mean of All Cows	Summer Cows	Winter Cows	Mean of All Cows	Summer Cows	Winter Cows	Mean of All Cows
1	4.2	4.7	4.4	40.78	33.21	36.99	217.0	217.5	217.2
2	4.2	5.0	4.6	40.64	34.46	37.55	217.8	217.5	217.6
3	3.3	3.9	3.6	40.75	34.60	37.68	219.6	220.3	219.9
4	2.9	4.7	3.6	41.15	35.22	38.18	219.7	221.4	220.6
5	4.0	4.4	4.2	42.04	35.26	38.65	220.8	222.7	221.7
6	4.6	5.0	4.8	42.36	35.27	38.81	220.8	223.5	222.1
7	4.9	4.4	4.7	42.46	35.59	39.02	220.1	224.1	222.1
8	4.3	4.8	4.6	42.46	36.16	39.31	219.2	223.6	221.4
9	4.0	4.4	4.2	42.30	36.99	39.64	219.4	222.3	220.9
10	4.1	4.6	4.3	42.45	36.61	39.53	219.4	222.9	221.1
Herd Av.				37.93	33.70		224.3	228.3	

TABLE XVII (Cont.)

Milking No.	Reich.-M Value			Polenske Value			Conjug. Dienoic,%		
	Summer Cows	Winter Cows	Mean of All Cows	Summer Cows	Winter Cows	Mean of All Cows	Summer Cows	Winter Cows	Mean of All Cows
1	19.0	17.0	18.0	1.2	1.2	1.2	0.64	0.44	0.54
2	21.8	18.5	20.1	1.0	1.2	1.1	0.61	0.46	0.53
3	24.2	22.2	23.2	1.0	1.3	1.1	0.58	0.47	0.52
4	25.2	24.2	24.7	1.0	1.3	1.1	0.60	0.50	0.55
5	25.7	26.2	25.9	1.0	1.2	1.1	0.59	0.51	0.55
6	25.9	28.4	27.1	1.0	1.3	1.1	0.60	0.52	0.56
7	26.3	29.4	27.8	0.9	1.2	1.0	0.61	0.53	0.57
8	26.9	29.8	28.3	1.0	1.2	1.0	0.63	0.55	0.59
9	27.0	29.2	28.1	1.0	1.1	1.0	0.65	0.55	0.60
10	26.5	29.3	27.9	0.9	0.8	0.9	0.65	0.53	0.59
Herd Av.	26.6	28.9		1.8	2.1		1.33	0.52	

TABLE XVII (Cont.)

Milking No.	Non-Conjug. dienoic Summer Cows	Winter Cows	Mean of All Cows	Non-Conjug. trienoic Summer Cows	Winter Cows	Mean of All Cows	Non-Conjug. tetraenoic,% Summer Cows	Winter Cows	Mean of All Cows
1	2.25	1.88	2.07	0.61	0.38	0.49	1.13	1.23	1.18
2	2.09	1.68	1.88	0.47	0.35	0.41	1.07	1.14	1.11
3	2.03	1.73	1.88	0.46	0.32	0.42	0.98	1.07	0.99
4	2.06	1.76	1.91	0.49	0.33	0.41	0.84	0.98	0.91
5	2.01	1.73	1.87	0.47	0.33	0.40	0.75	0.94	0.84
6	1.94	1.74	1.84	0.50	0.36	0.43	0.69	0.86	0.77
7	1.82	1.66	1.73	0.55	0.37	0.46	0.63	0.77	0.70
8	1.85	1.56	1.68	0.55	0.39	0.47	0.53	0.64	0.69
9	1.66	1.59	1.71	0.51	0.37	0.44	0.48	0.61	0.54
10	1.67	1.51	1.61	0.47	0.45	0.46	0.48	0.56	0.52
Herd Av.	1.02	1.34		0.55	0.55		0.25	0.39	

TABLE XVIII.

Fat Constants and Unsaturated Fatty Acid Composition of the Milkfat of the University of Manitoba Herd.

Sampling Date	Fat Constants: Iodine Value	Sapon. Value	Reich.-Meissl Value	Polenske Value	Unsaturated Fatty Acids, Weight % of Fat. Conjugated: Dienoic	Trienoic	Tetra-enoic	Non-Conjugated: Dienoic	Trienoic	Tetra-enoic	"Mono-enoic	Total Unsat.
Oct.1953	33.70	221.0	25.6	2.4	0.90	0.03	trace	1.77	0.76	0.50	29.84	33.80
Nov.1953	34.10	230.5	27.7	2.2	0.56	0.03	"	2.24	0.96	0.56	29.26	33.61
Dec.1953	33.00	226.7	29.1	2.2	0.44	0.01	"	1.40	0.34	0.31	30.81	33.31
Jan.1954	34.00	227.6	29.9	2.0	0.55	0.02	"	1.40	0.36	0.29	31.93	34.55
Feb.1954	35.20	227.2	29.4	2.3	0.55	0.02	"	1.19	0.39	0.25	33.42	35.92
Mar.1954	37.10	224.1	28.3	1.7	0.69	0.03	"	1.30	0.52	0.30	34.55	37.39
Apr.1954	34.50	224.4	29.2	2.1	0.63	0.02	"	1.18	0.58	0.31	31.70	34.42
May 1954	33.10	226.7	30.4	2.3	0.65	0.02	"	1.15	0.40	0.33	30.56	33.11
June 1954	32.90	226.1	29.0	2.0	0.60	0.03	"	1.08	0.64	0.12	30.77	33.24
July 1954	39.50	224.8	24.9	1.2	1.11	0.04	"	1.60	0.22	0.36	36.24	39.61
Aug.1954	41.40	222.0	26.0	1.2	2.28	0.04	"	0.38	0.79	0.26	37.20	40.95
Sept.1954	40.40	221.8	25.4	1.3	1.27	0.02	"	1.44	0.77	0.43	35.54	39.47
Oct. 1954	37.80	224.0	25.4	-	0.87	0.02	"	1.64	0.74	0.26	33.89	37.42

TABLE XIX.

Analysis of Variance of the Fat Content.

Source:	d.f.	M.S.	F	F(1%)
Cows	6	9.55	12.57	3.13
Season	1	5.13	6.75	7.10
Milkings	9	1.59	2.09	2.73
Error	58	0.76		

d.f. = degrees of freedom; Y = Value or content;

M.S. = Mean Square; Y_i = Y averaged over cow i;

$F = \frac{\text{M.S.}}{\text{M.S. (error)}}$; X = Milking number.

TABLE XX.

Analysis of Variance of the Iodine Value.

(for abbrev. see Table XIX).

Source:	d.f.	M.S.	F	F(1%)
Cows	6	235.59	150.72	3.10
Season	1	819.90	524.53	7.06
Milkings	9	6.53	4.18	2.71
Error	62	1.56		

Regression Equation: $Y_e = -1.61 + Y_i + 0.2927\ X.$

TABLE XXI.

Analysis of Variance of the Saponification Value.

(For abbrev. see Table XIX).

Source:	d.f.	M.S.	F	F(1%)
Cows	6	76.02	22.55	3.11
Season	1	96.31	28.45	7.07
Milkings	9	24.13	7.14	2.71
Error	61	3.38		

Regression Equation: $Y_e = -5.4609 + Y_i + 1.9890\ X - 0.1423\ X^2$.

TABLE XXII.

Analysis of Variance of the Reichert-Meissl Value

(For abbrev. see Table XIX).

Source:	d.f.	M.S.	F	F(1%)
Cows	6	45.04	12.42	3.12
Season	1	155.09	42.70	7.08
Milkings	9	105.22	29.05	2.72
Error	59	3.64		

Regression Equation: $Y_e = -10.1494 + Y_i + 3.1493\ X - 0.1863\ X^2$.

TABLE XXIII.

Analysis of Variance of the Polenske Value.

(For abbrev. see Table XIX).

Source:	d.f.	M.S.	F	F(1%)
Cows	6	1.17	39.0	3.12
Season	1	0.59	19.7	7.08
Milkings	9	0.07	2.3	2.72
Error	59	0.03		

TABLE XXIV.

Analysis of Variance of the Conjugated Dienoic Fatty Acid Content.

(For abbrev. see Table XIX).

Source:	d.f.	M.S.	F	F(1%)
Cows	6	0.1403	58.5	3.10
Season	1	0.2587	107.8	7.06
Milkings	9	0.0044	1.8	2.71
Error	62	0.0024		

TABLE XXV.

Analysis of Variance of the Non-Conjugated Dienoic Fatty Acid Content

(For abbrev. see Table XIX).

Source:	d.f.	M.S.	F	F(1%)
Cows	6	0.8949	22.65	3.10
Season	1	1.2624	31.95	7.06
Milkings	9	0.1423	3.60	2.71
Error	62			

Regression Equation: $Y_e = 0.2272 \neq Y_i - 0.0413$ X.

TABLE XXVI.

Analysis of Variance of the Non-Conjugated Trienoic Fatty Acid Content

(For abbrev. see Table XIX).

Source:	d.f.	M.S.	F	F(1%)
Cows	6	0.1450	26.85	3.10
Season	1	0.4322	80.03	7.06
Milkings	9	0.0078	1.44	2.71
Error	62	0.0054		

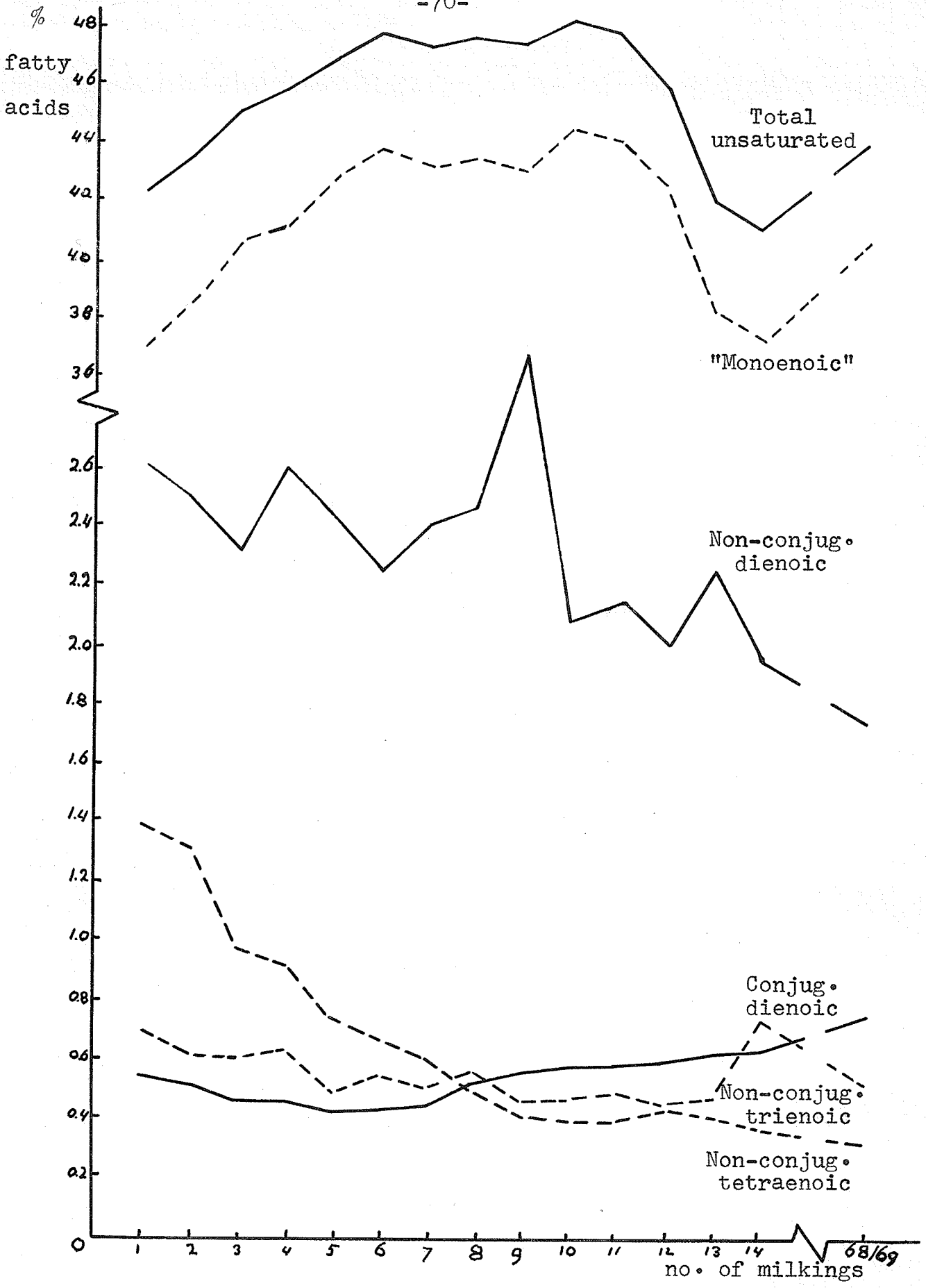
TABLE XXVII.

Analysis of Variance of the Non-Conjugated Tetraenoic Fatty Acid Content

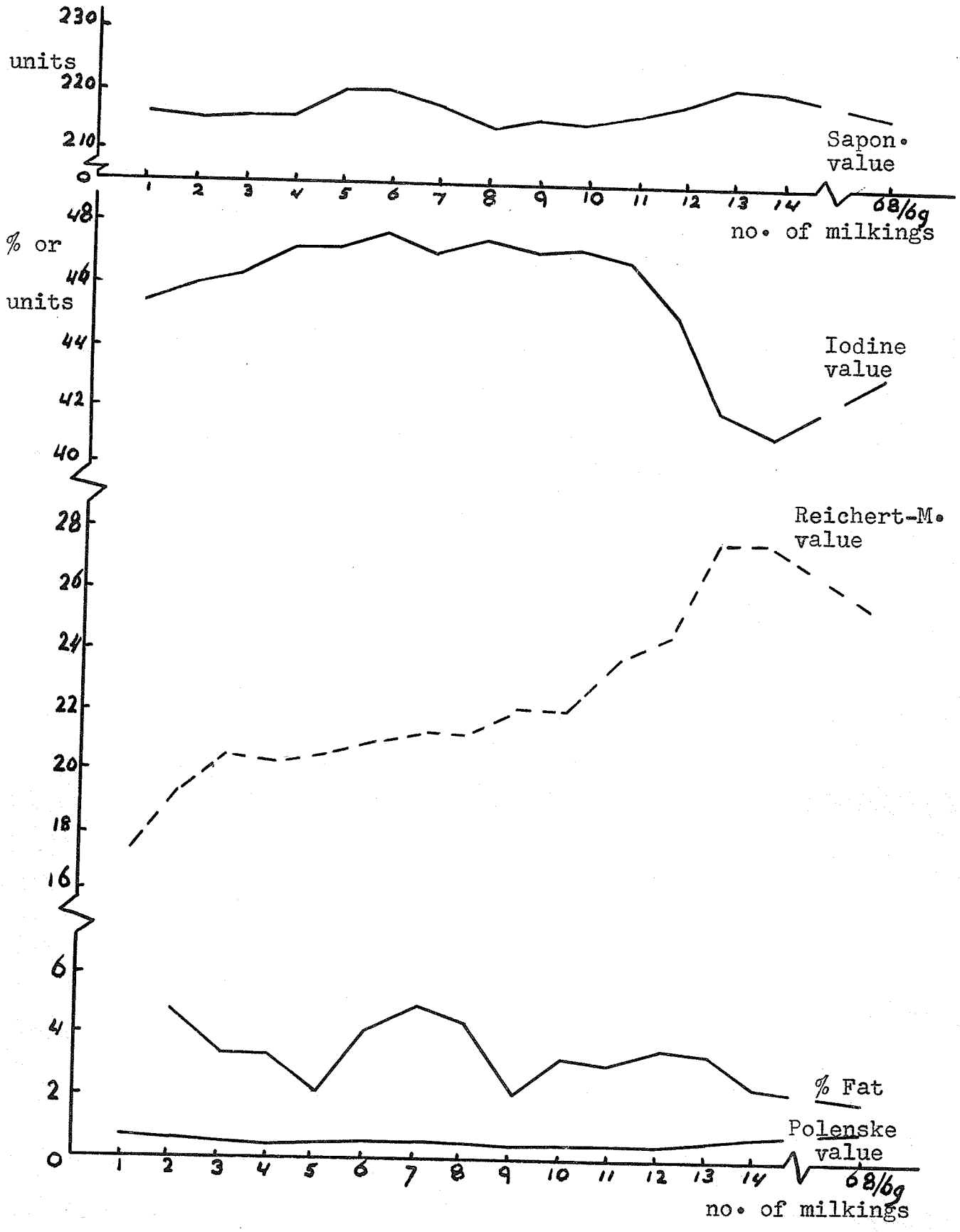
(For abbrev. see Table XIX).

Source:	d.f.	M.S.	F	F(1%).
Cows	6	0.2258	17.10	3.10
Season	1	0.2953	22.37	7.06
Milkings	9	0.4298	32.56	2.71
Error	62	0.0132		

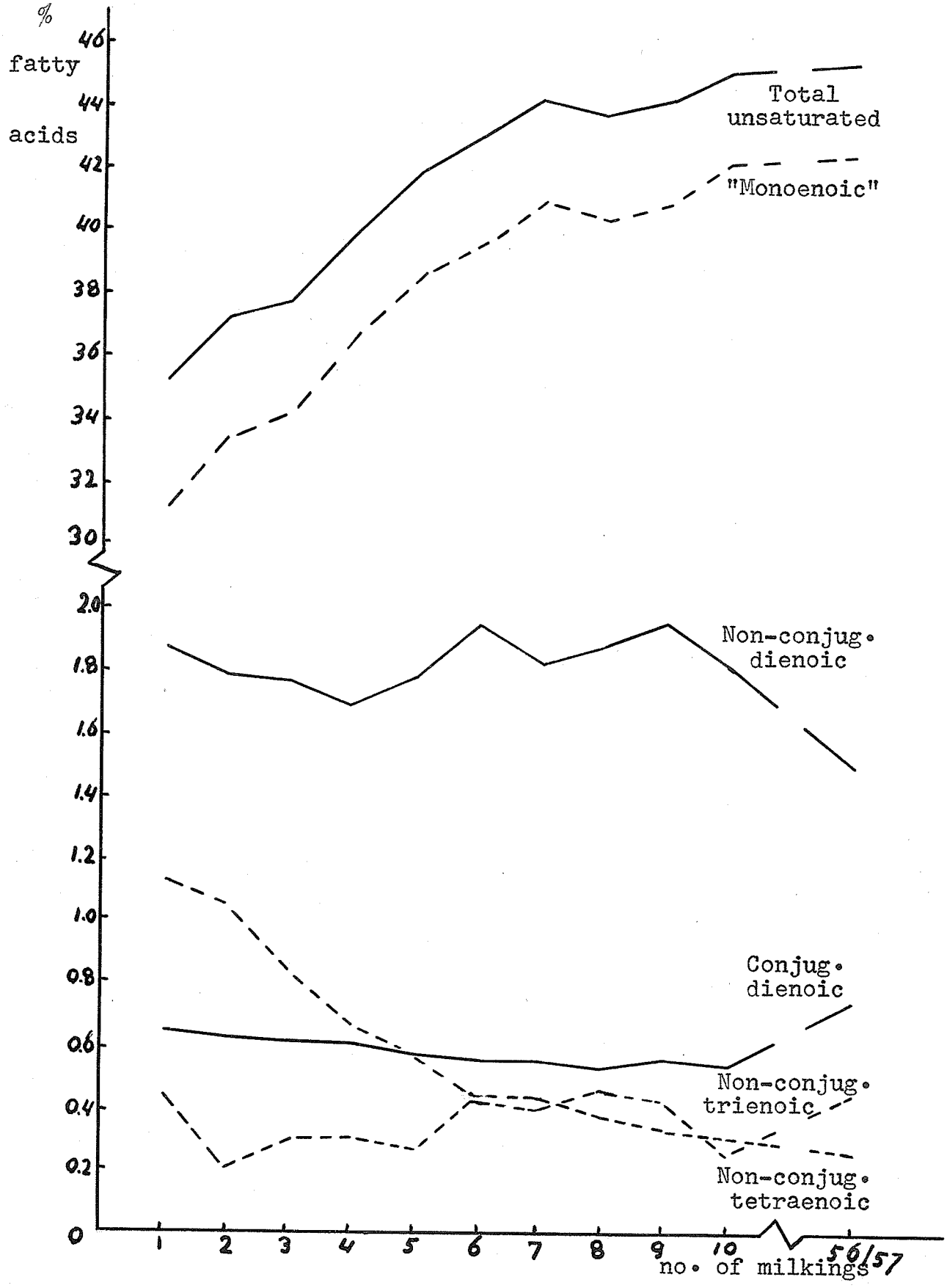
Regression Equation: $Y_e = 0.4191 \neq Y_i - 0.0762\ X.$



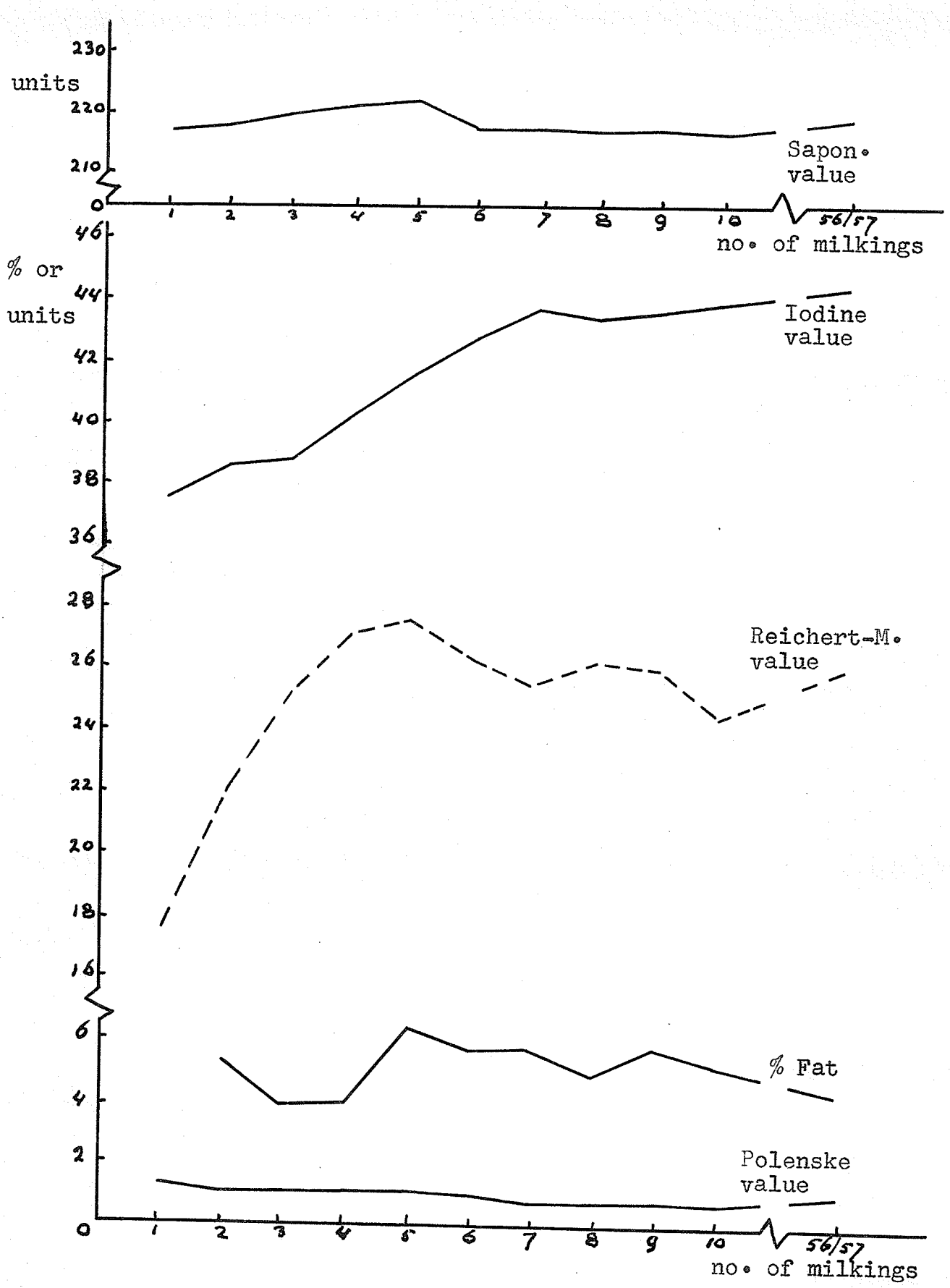
Graph I. Unsaturated fatty acid composition of the colostrumfat of cow no 1.



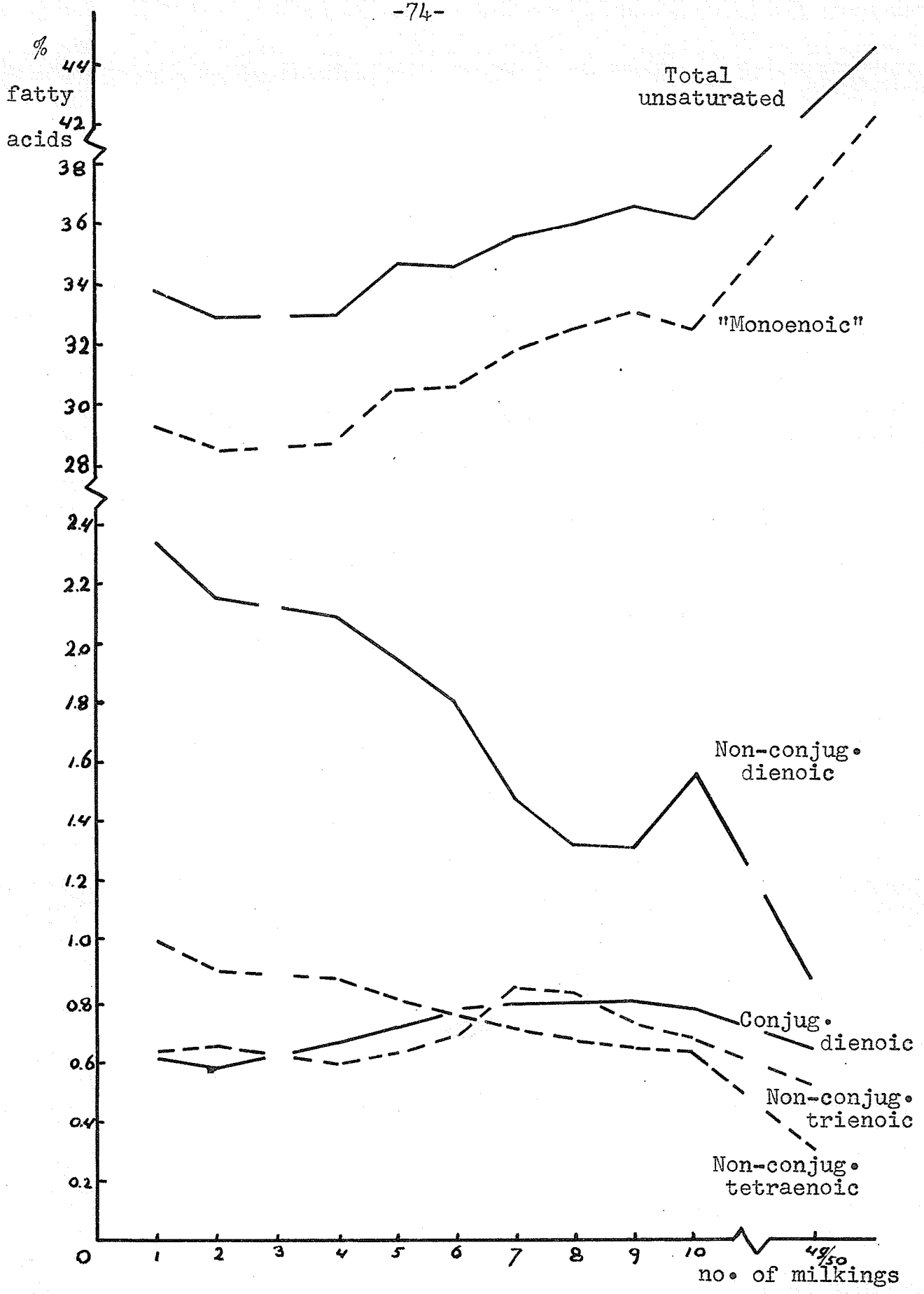
Graph II. Fat constants of the colostrumfat of cow no. 1.



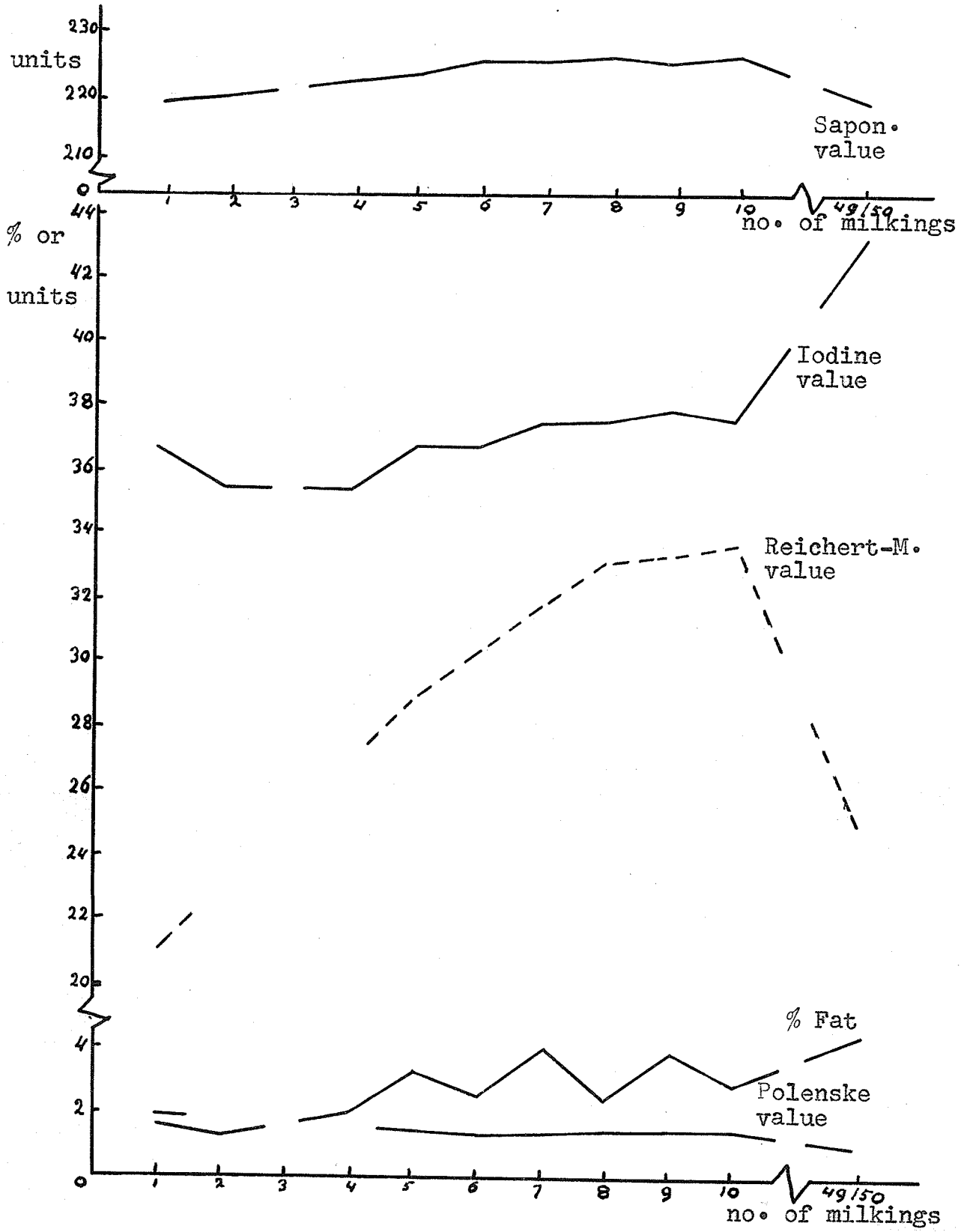
Graph III. Unsaturated fatty acid composition of the colostrumfat of cow no. 2.



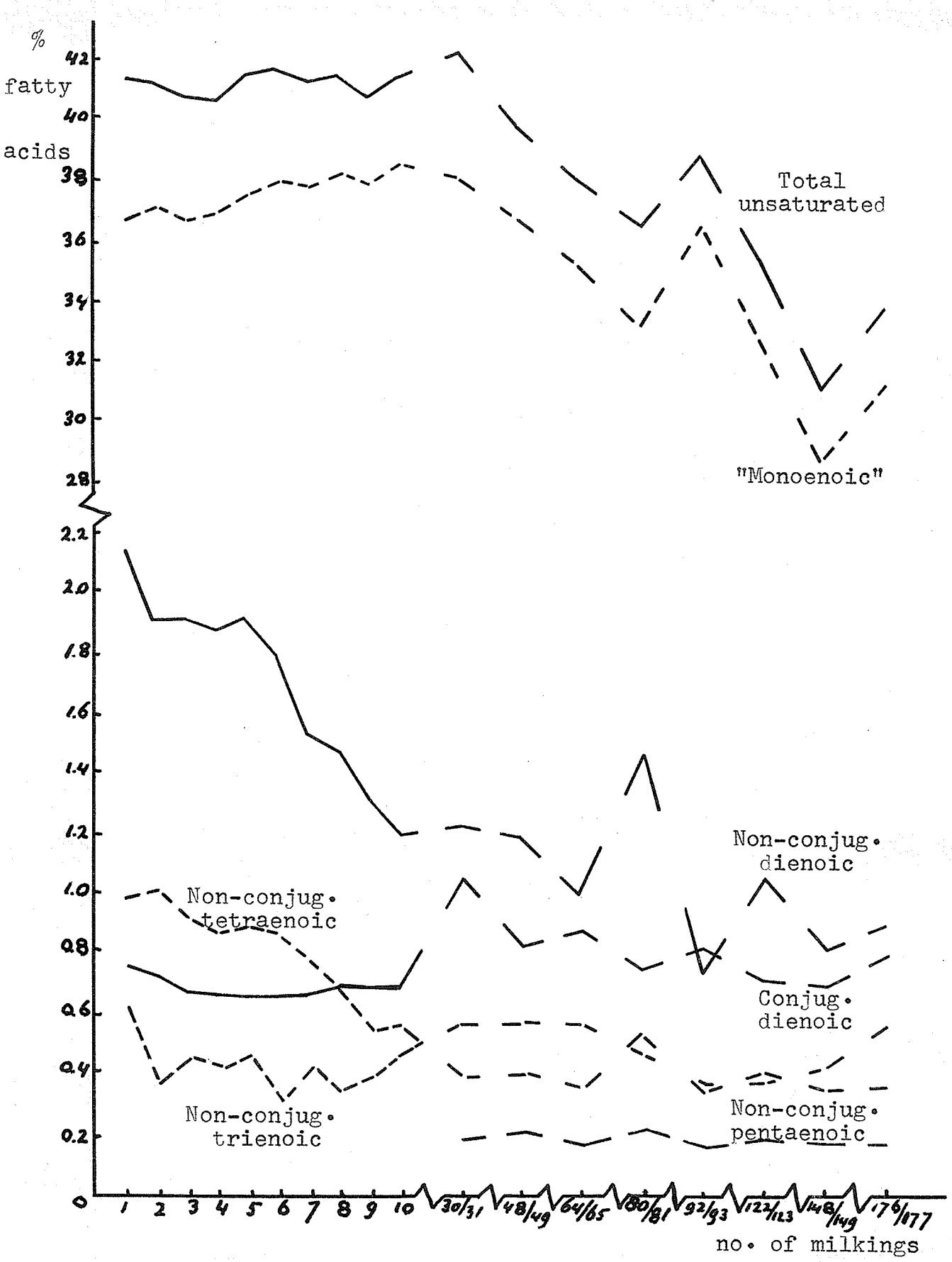
Graph IV. Fat constants of the colostrumfat of cow no. 2.



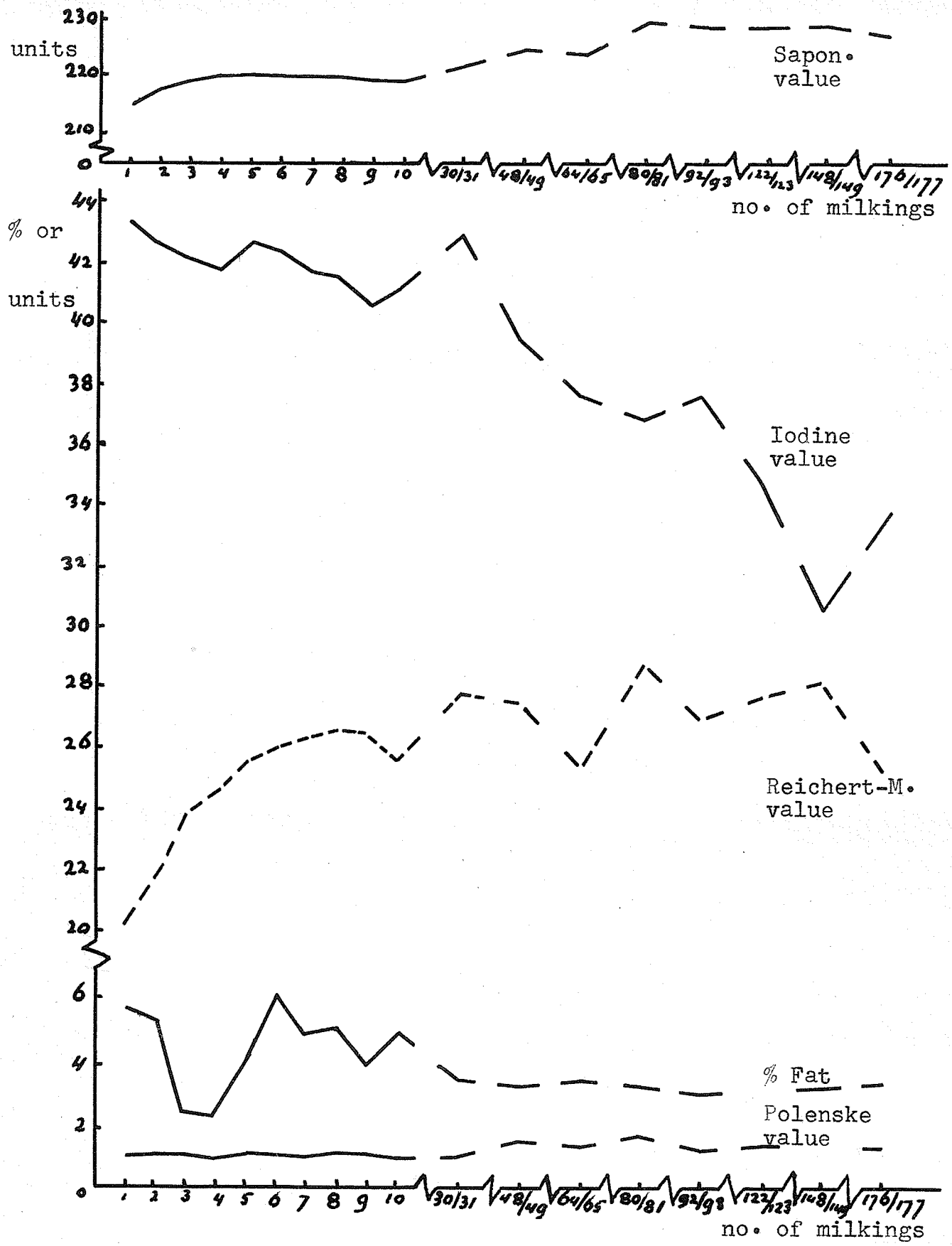
Graph V. Unsaturated fatty acid composition of the colostrumfat of cow no. 3.



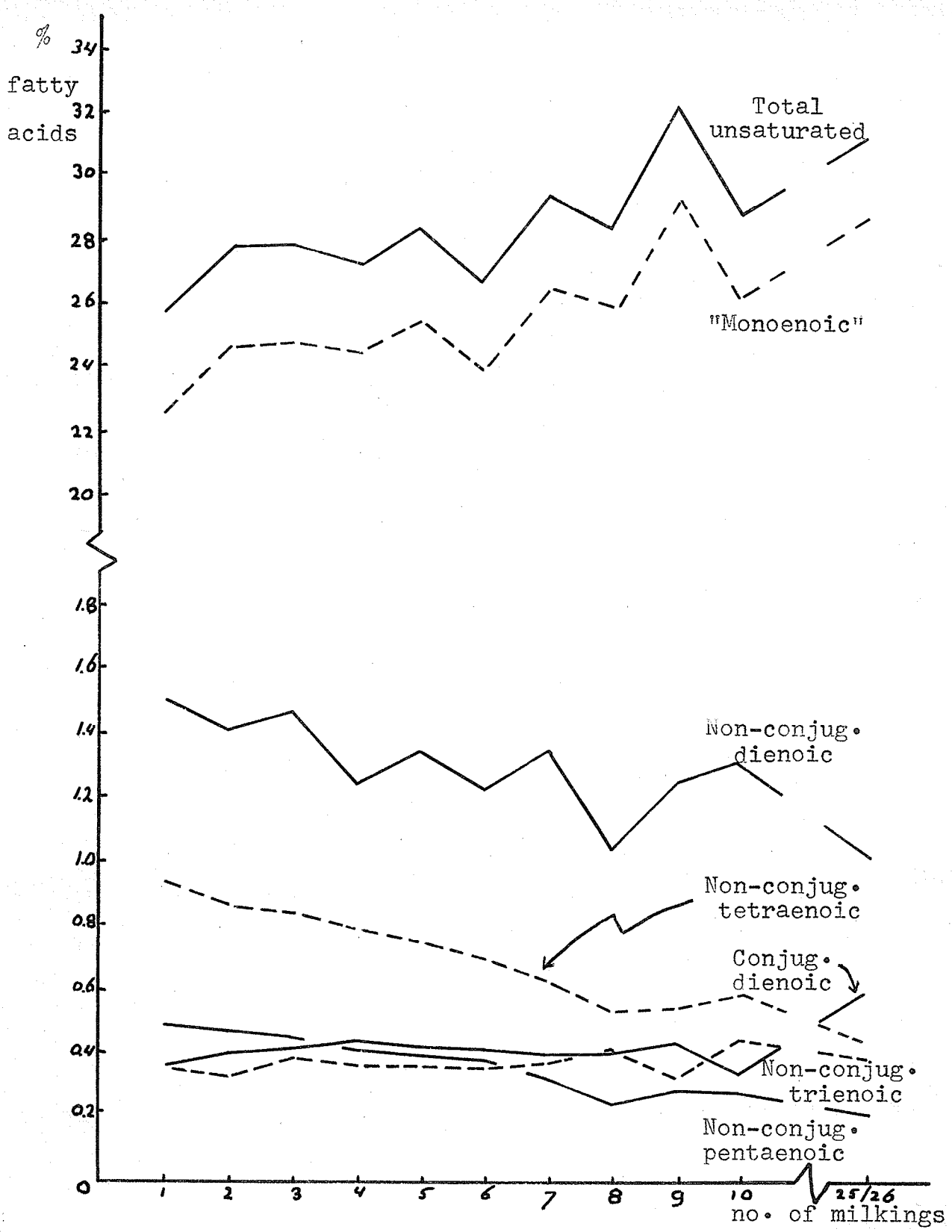
Graph VI. Fat constants of the colostrumfat of cow no. 3.



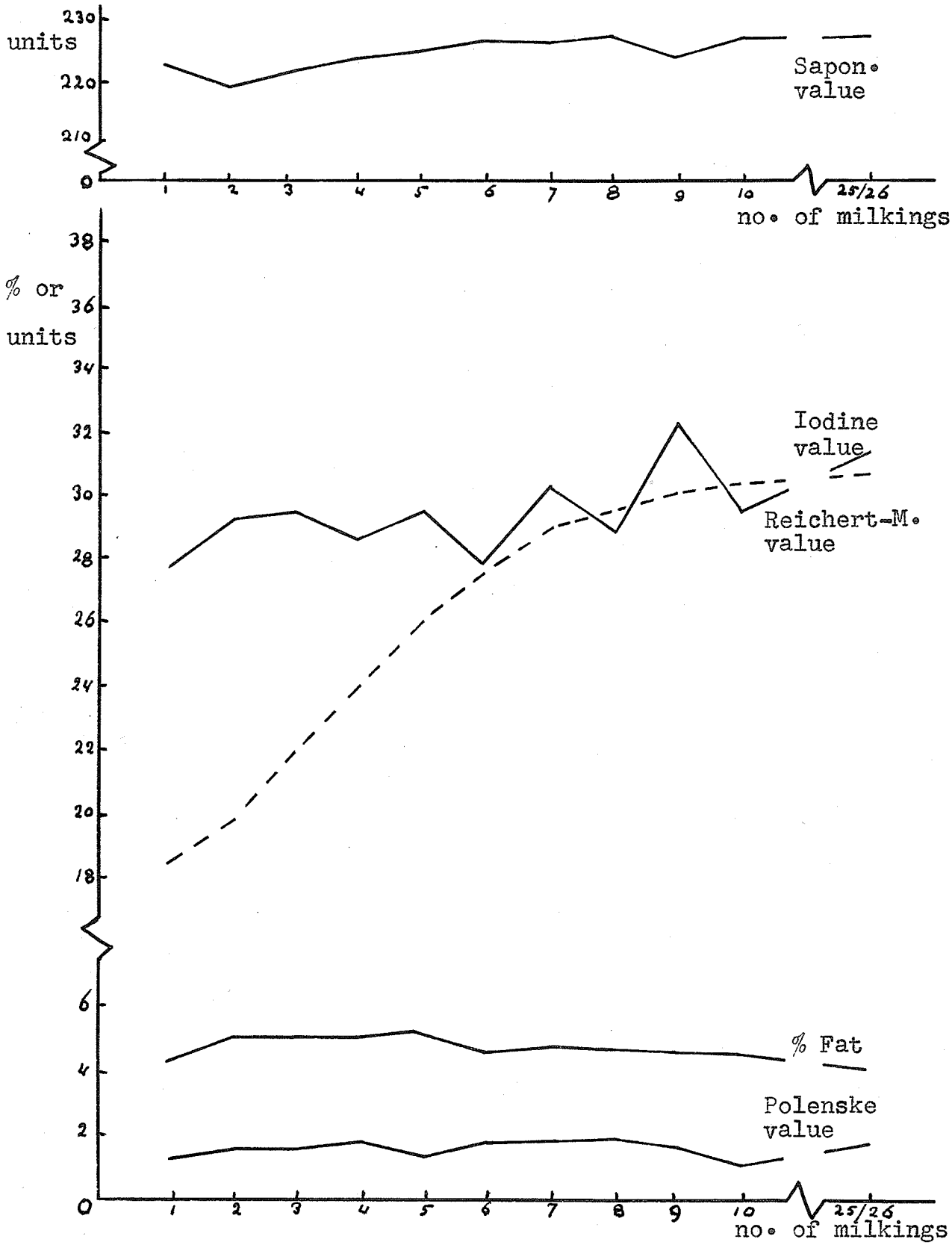
Graph VII. Unsaturated fatty acid composition of the colostrumfat of cow no. 4.



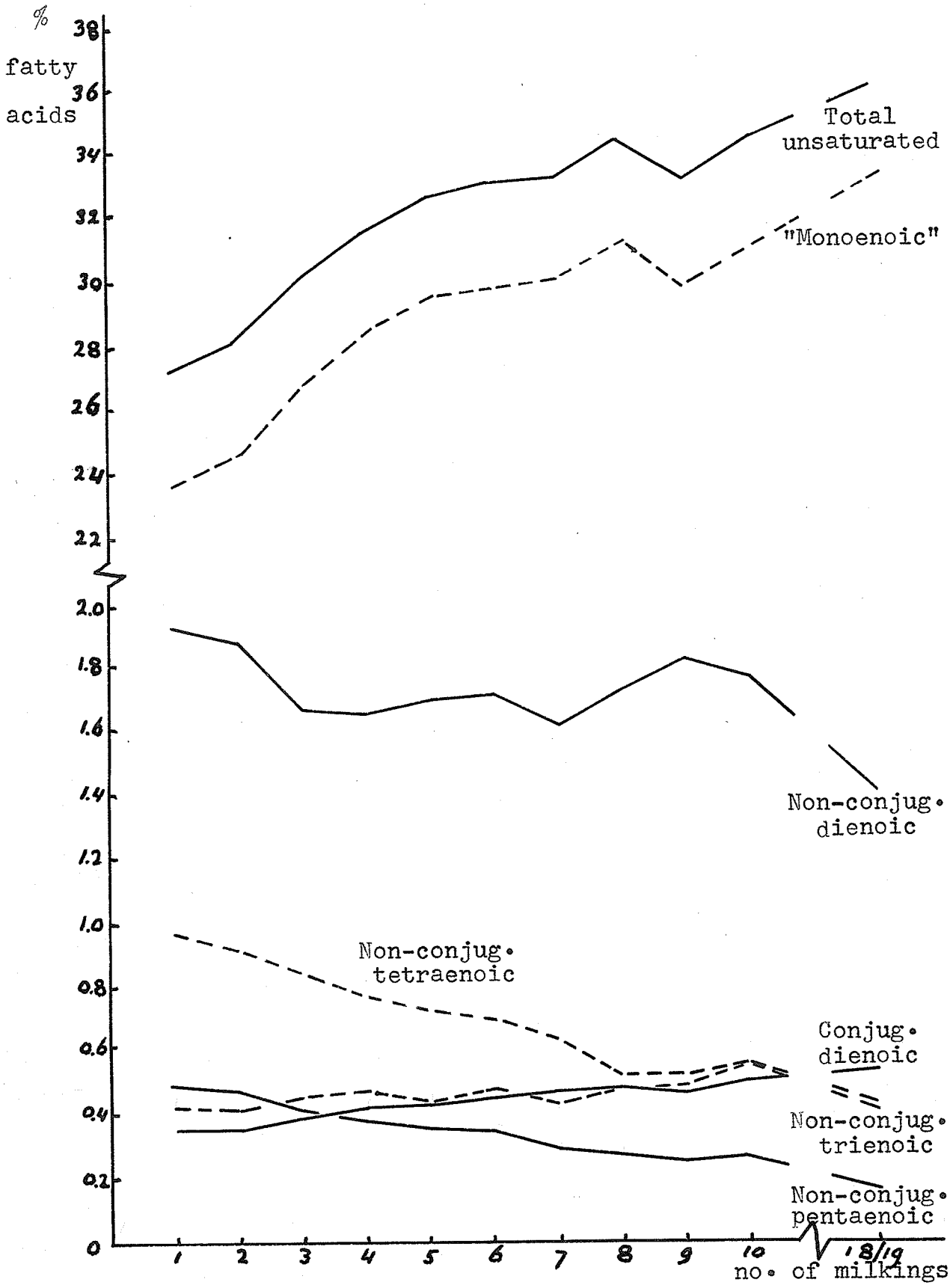
Graph VIII. Fat constants of the colostrumfat of cow no. 4.



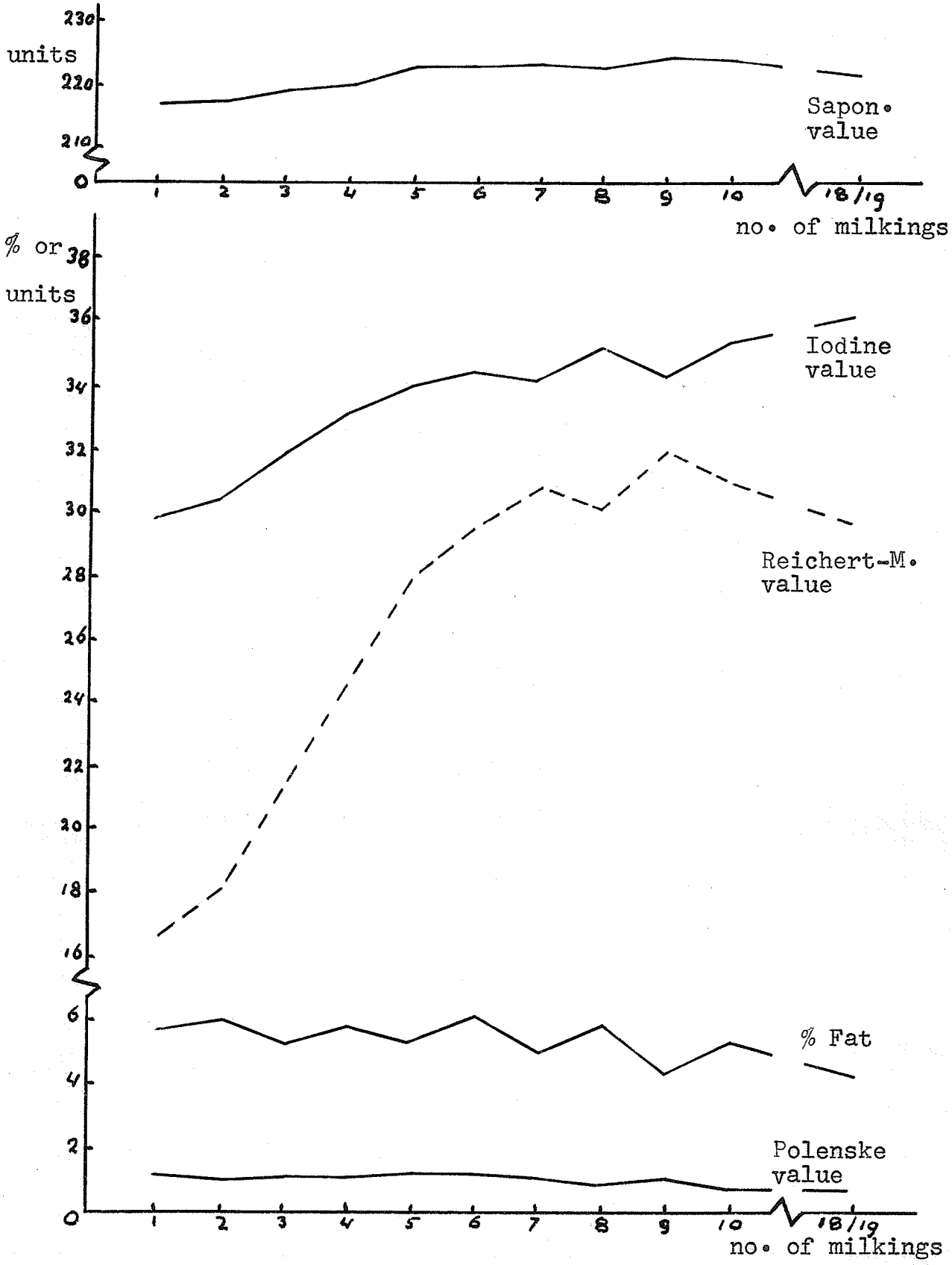
Graph IX. Unsaturated fatty acid composition of the colostrumfat of cow no. 5.



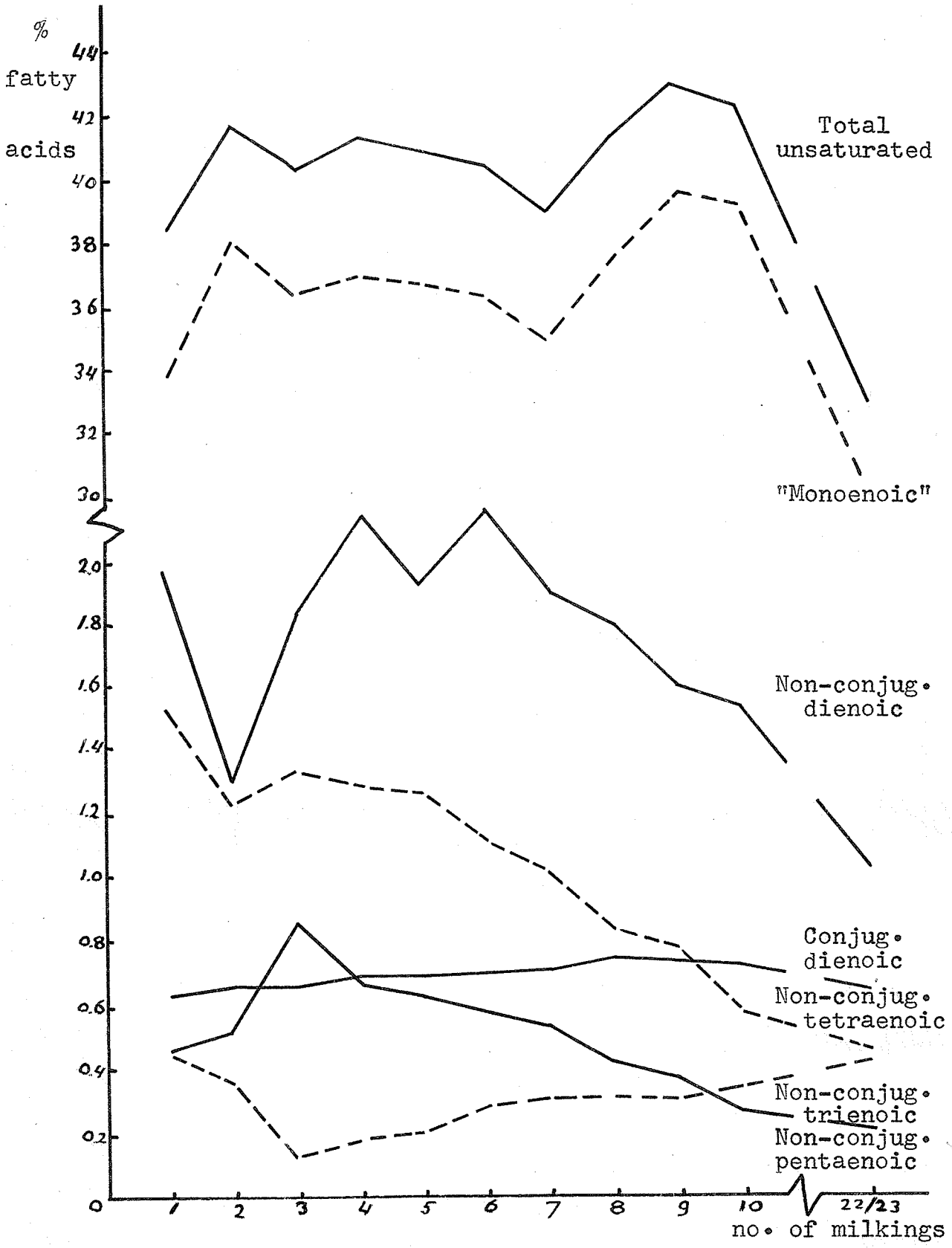
Graph X. Fat constants of the colostrumfat of cow no. 5.



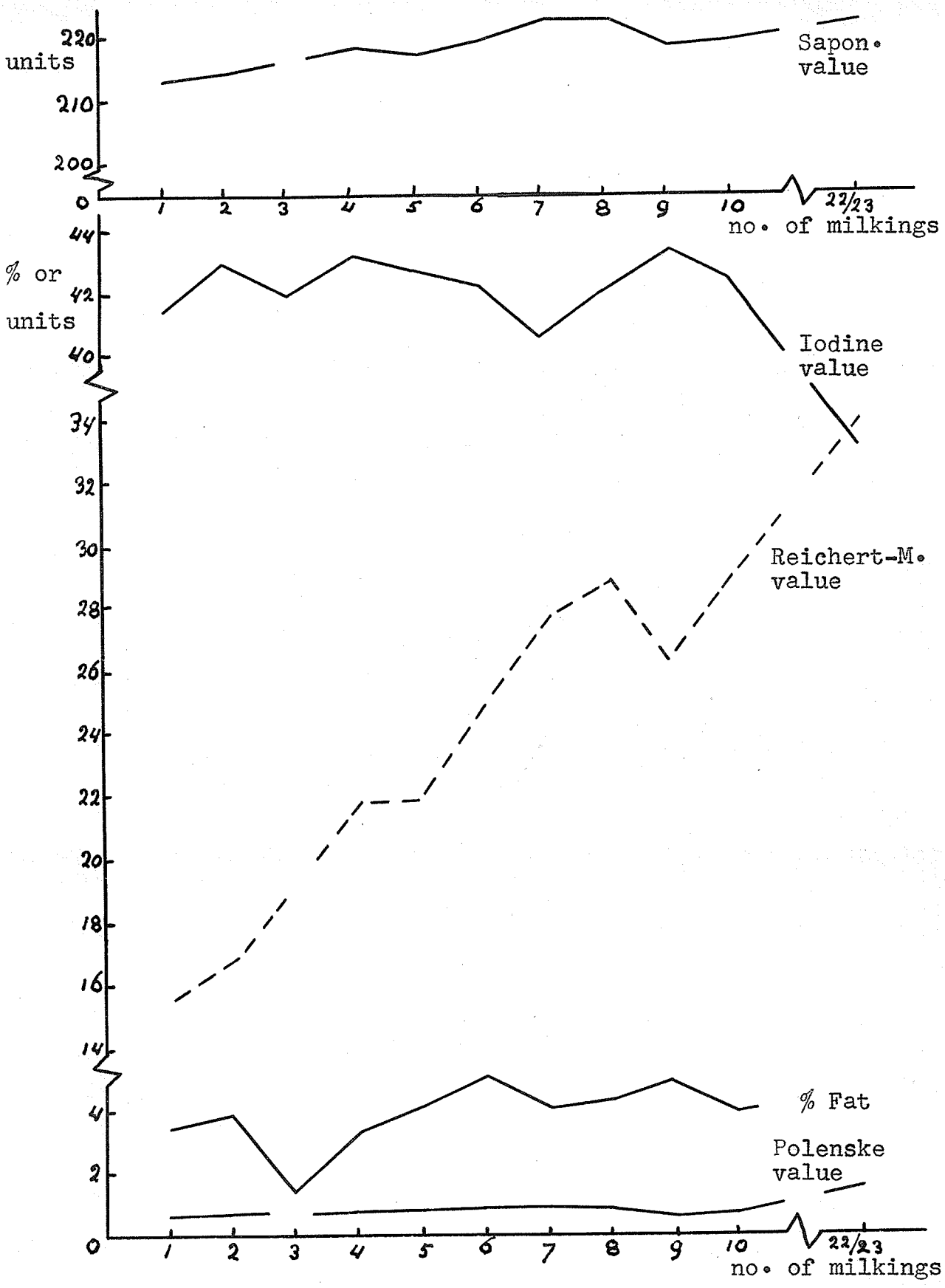
Graph XI. Unsaturated fatty acid composition of the colostrumfat of cow no. 6.



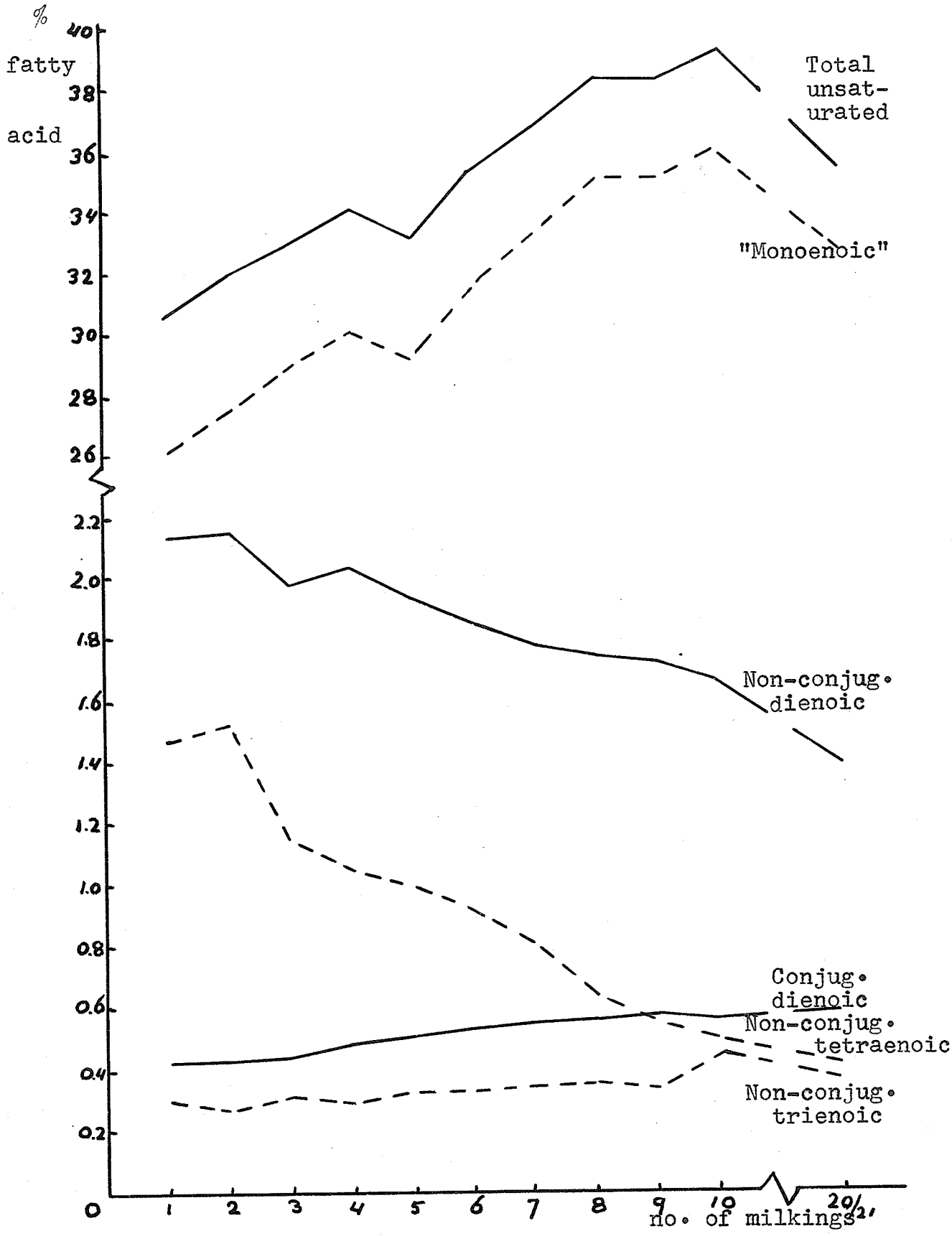
Graph XII. Fat constants of the colostrumfat of cow no. 6.



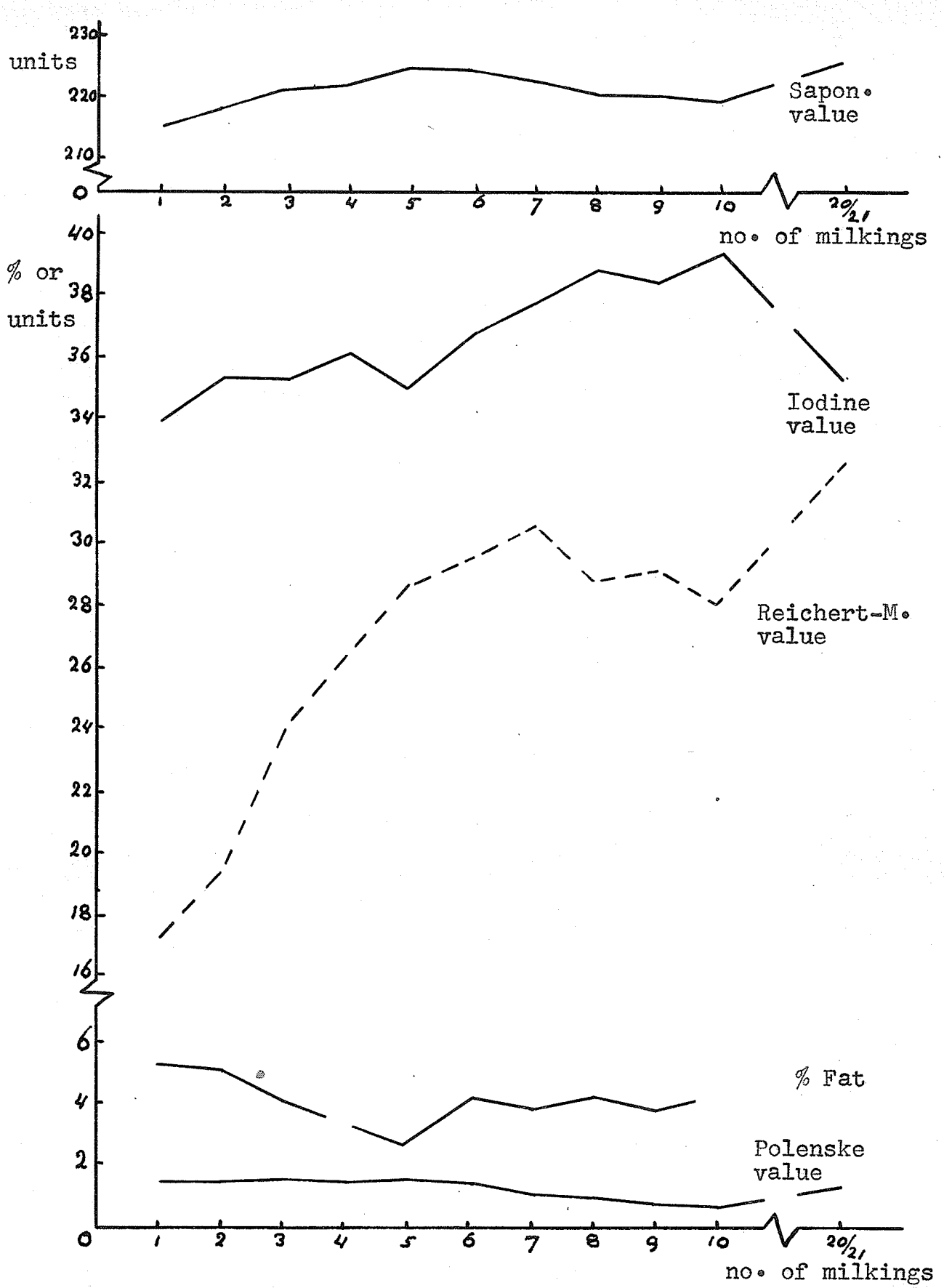
Graph XIII. Unsaturated fatty acid composition of the colostrumfat of cow no. 7.



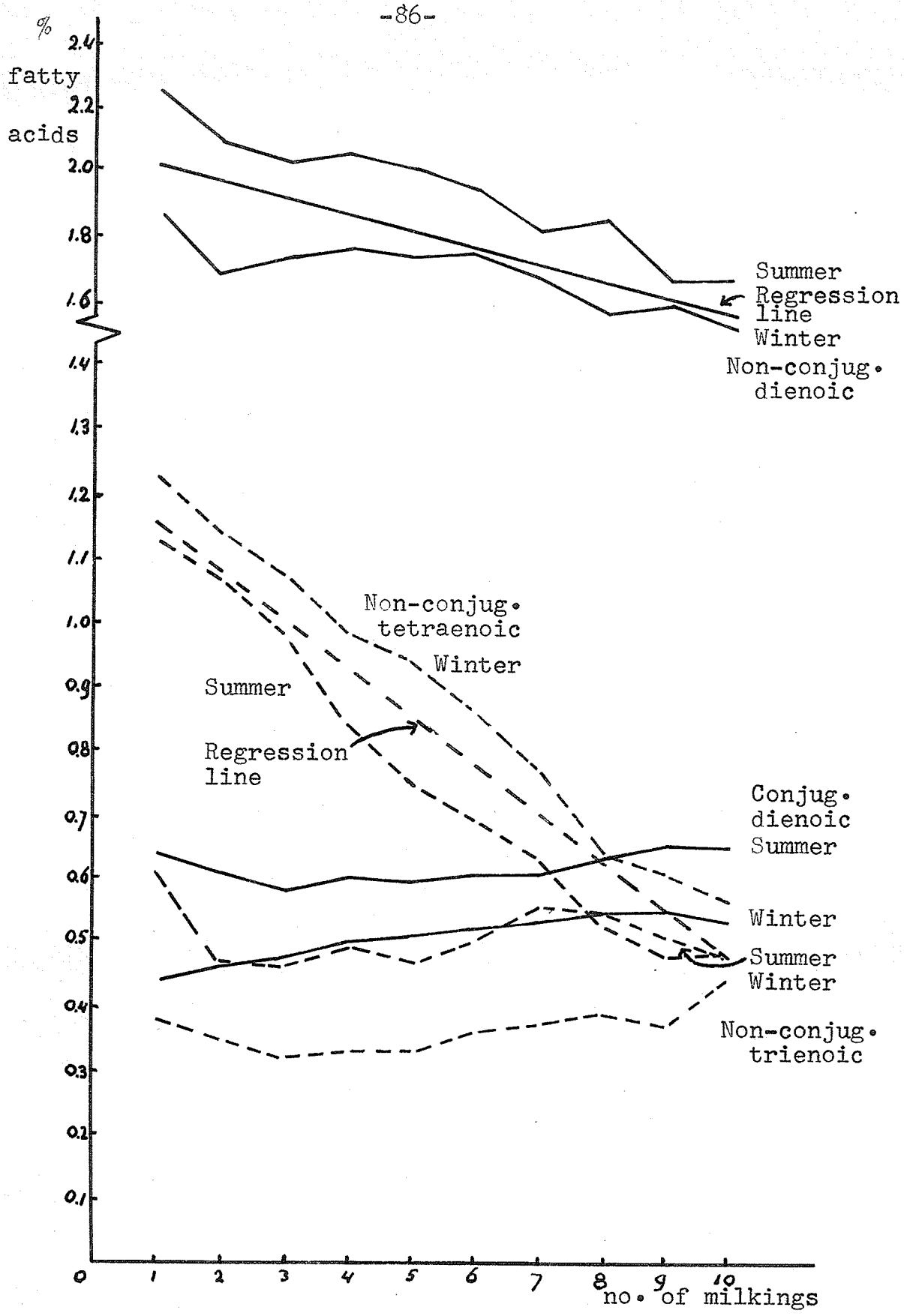
Graph XIV. Fat constants of the colostrumfat of cow no. 7.



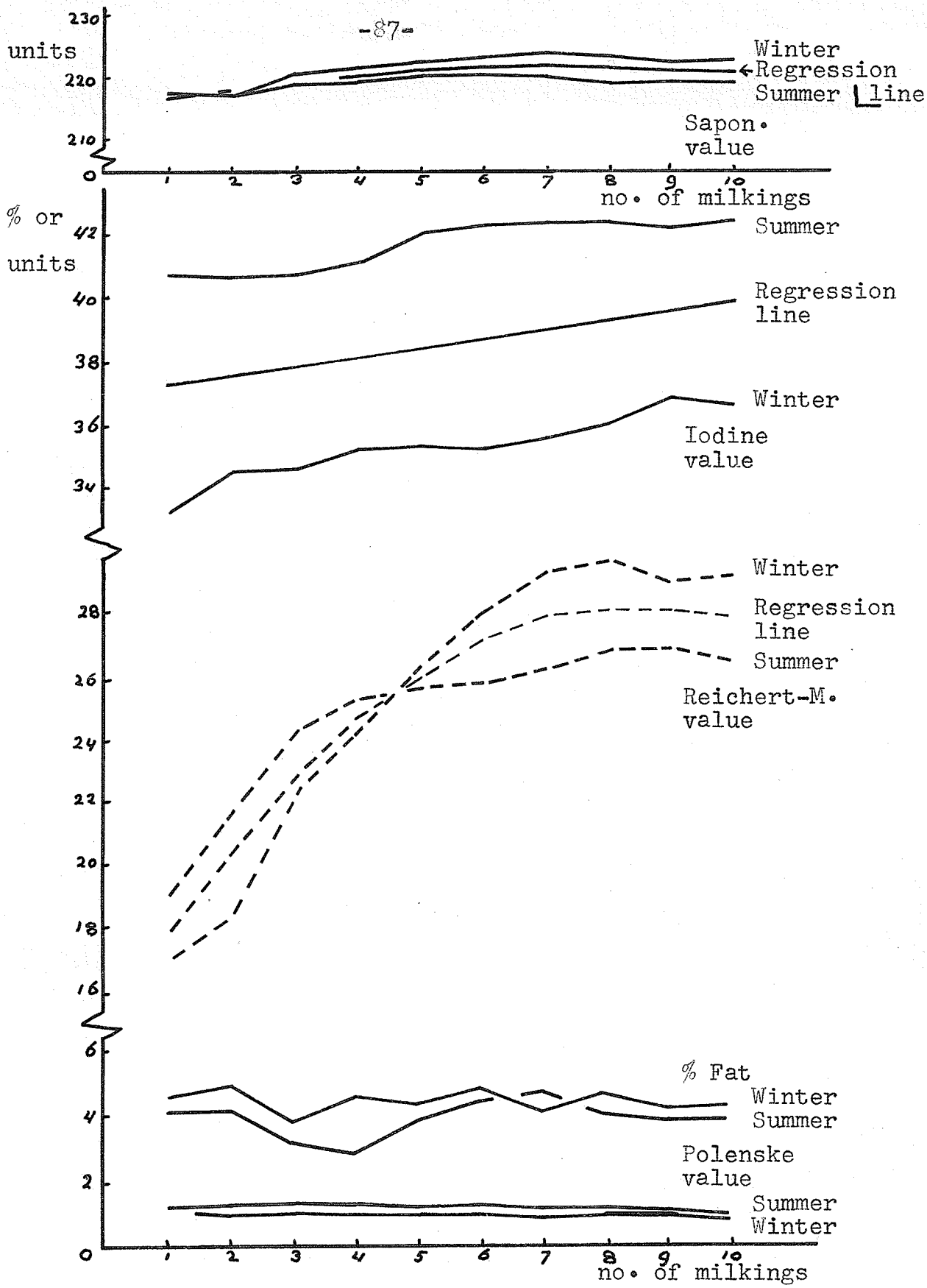
Graph XV. Unsaturated fatty acid composition of the colostrumfat of cow no. 8.



Graph XVI. Fat constants of the colostrumfat of cow no. 8.



Graph XVII. Unsaturated fatty acid composition of the colostrumfat averaged over the summer and the winter calving cows.



Graph XVIII. Fat constants of the colostrumfat averaged over the summer and the winter calving cows.