

A STUDY OF VARIATIONS IN A GROUP OF FEED FORMULAS
FOR QUALITY CONTROL PURPOSES

by 1264

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B. S., Universidad de San Carlos de Guatemala, 1966

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Grain Science and Industry

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1970

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INTRODUCTION

A continuous increase in knowledge of the nutritional requirements of animals, the use of computers in feed formulation and growing competition have made it necessary that rations be formulated under more exact requirements. Increasing competition exerts pressure over the feed manufacturers to improve quality without raising prices of product. Due to these factors a great concern related to quality control has developed within the feed industry. Quality control is the achievement of a uniform and consistent standard of product quality in accordance with the purpose for which it was formulated, manufactured and marketed.

The variations of the proximate analysis components in cereal grains and legumes have been determined (2); however, little similar data for processed complete feeds and supplements has been published. It is important for the small feed manufacturers who do not have quality control records, to know the degree of variation they can expect in finished feeds in order to formulate so they can meet guarantee requirements without excessive overformulation. It is also important for larger feed manufacturing companies, that keep quality control records, to have a point of comparison to know how well they are operating.

Data available for this study was limited and also most of the factors that could have affected the values of this data were unknown. Therefore this work does not pretend to draw any definite conclusions; instead, since quality control is a dynamic rather than a static concept, the purpose of this study is to im-

prove our knowledge about the variations in proximate analyses components as a first step in reaching a better basis for improving quality control programs.

REVIEW OF LITERATURE

The variation in chemical composition of feed ingredients has been considered recently by the feed industry as one of the most important problems in producing high quality feeds that meet guarantees and uniform specifications.

Miller et al (1) studied variations in protein levels in Kansas sorghum grain. Wide variations in protein content were found. The range was from 6.6 to 12.8% in 1961 and from 5.9 to 12.1% in 1962. These differences were attributed mainly to different locations, different hybrids and fertilization.

Deyoe (2) reported variations in the composition of feed ingredients, both from animal and vegetable origin. These variations in protein are shown in the following table:

<u>Ingredient</u>	<u>Number of Samples</u>	<u>Mean</u>	<u>Range High - Low</u>	<u>Standard Deviation</u>
Fish Meal - 60%	20	60.0	62.2 - 58.8	0.89
Fish Meal - 65%	12	66.3	69.6 - 64.5	1.54
Meat & Bone Scraps - 50%	83	51.4	58.7 - 44.2	2.33
Tankage - 60%	11	61.4	64.0 - 58.6	1.52
Soybean Meal - 44%	81	45.6	53.5 - 42.5	1.55
Cottonseed Meal - 41%	148	42.3	45.2 - 38.2	1.21
Alfalfa Meal - 17%	21	17.9	20.4 - 15.5	1.28
Wheat Bran	27	17.2	21.2 - 15.8	1.03
Wheat Middlings	16	18.1	19.9 - 17.2	2.76
Corn (1962)	95	8.4	10.0 - 6.4	0.70
Milo (1962)	231	9.0	12.1 - 5.9	1.63

Carbohydrate and protein changes have been observed in grain

during storage but no appreciable mineral changes have occurred, except under very unusual conditions, as stated by Zeleny (3).

Chung and Pfost (4) proposed three methods in order to minimize the effect that variations of feed ingredients may have in the finished product:

- a) By blending several loads of a single ingredient before using. This blending may be approximated by simply storing ingredients in large diameter bins and depending on flow out of the bin to supply the required mixing.
- b) Segregate the loads of incoming ingredients into "above average" and "below average" bins. This can be accomplished using quick protein methods. Formulation of ration would specify which bin to be used.
- c) Make the rations using different ingredients, for example different protein sources.

✧ In research at a local elevator and feed mill, Page et al (5) studied the feasibility of applying fast methods for protein analysis with the purpose of evaluating and segregating incoming harvested grain on a practical basis. It was found that arriving grain could be evaluated and separated using quick protein analysis. It was also found that sampling one fourth of the loads arriving might be enough.

The effect that protein in grain sorghum might have on ingredient values and cost of finished feed was estimated by Schoeff (6). His estimates showed that sorghum grain ranging from 5 to 11% protein might produce differences as great as \$6.40/ton in ingredient value. Also, differences over \$3.50/ton of finished feeds

could occur depending on the proportion of sorghum grain used in the ration.

Using the information gathered by Page et al (5) and the statistical approach proposed by Chung and Pfost (4), Page et al (7) showed how cost could be reduced and quality control improved by blending grain which had been classified by protein analysis. This study also indicated the type of plant operation required to perform the job.

Zeigler (8) mentioned the following areas as some of the most important for improvement of the quality of finished products: representative sampling; testing and analysis of feed ingredients; methods to overcome ingredient variations; protein, vitamin and mineral levels related to energy content of the diet as means of proper formulation; moisture as one of the primary factors which affect energy content and the problem of non-protein nitrogen in the actual methods of protein determination.

In order to overcome the effect of ingredient variation on finished feeds, Nott and Combs (9) proposed a logical adjustment on each feed ingredient based on its inherent variability. With this method feeds are formulated using ingredient composition data which has been adjusted by subtracting one half standard deviation from the mean value of the ingredient in the cases where it is not desirable that the average analysis of the mixed feed go below a determined specification, for example protein, ether extract, etc.; and by adding one half standard deviation in the cases where it is not desirable to go above certain specification, for example fiber, ash, moisture.

Another very important area for overall quality control is in process control. The first step in this area is in personnel instruction and attitude development. Probably the most important areas in which personnel involvement is most critical are: weighing for mixing, pelleting, sampling and equipment maintenance.

Bender (10) stated that it is essential that the people in the manufacturing areas clearly understand the need and importance of quality. It is also essential that they be thoroughly indoctrinated with the importance of their operation and its relationship to the quality of the final product.

Furthermore, Nolte (11) stated that the greatest opportunity for improving or maintaining acceptable quality is in the areas of training and motivation of manpower. Good communications, training, personal attention and adequate facilities are cited as important management tools for personnel improvement.

The emphasis placed by management on the quality control program and the education program for every man who handles feeds, was expressed by Rohlinger (12) as the primary factor in a good quality control program.

Harris and Chaney (13) said that in spite of the great improvement in technology and the rapid advance of automation, human performance is still a critical factor in product quality and reliability. They recognize the importance of personnel improvement through training and motivation, but they see greater potential for improvements through changes in the job and its environment.

Other important areas of process control are mixing and

pelletting.

The importance of good mixing is recognized among animal nutritionists and feed manufacturers. Arbitrary limits to measure mixer performance have been set by Bloom & Livesey (14) and Merck's Service Bulletin (15). The former said that 90% or more of the animal daily requirements of the ingredient considered should be present in 95% of the daily rations received by the animal; the latter stated that a coefficient of variation of less than 5% probably represents a good mix.

In further study, Pfof (16) stated that the coefficient of variation should not be more than 20% to avoid possible toxic effects when the number of particles of the component expected in the sample was not very large. If usual numbers of components are present per sample the coefficient of variation that may be allowed due to poor mixing and/or segregation could range as high as 5 to 10%.

Wornick (17) summarized the major problems associated with feed mixing. Product complexity, equipment characteristics and inadequate quality control procedures were cited.

Pfof et al (18) stressed the importance of the physical properties of feed ingredients in relation to problems of mixing. Particle size, shape, specific weight, hygroscopicity, susceptibility to electrostatic charges and adhesiveness were the properties cited. In that work the physical properties of some common microingredients and ingredients were determined. From those properties they concluded that minerals because of their small particle size and high density should be a critical factor in

mixing.

Clump (19) stated that the performance of dry solids mixing equipment is affected by a number of variables of which the most important are: particle properties and size distribution, the equipment geometry, rotation and speed of the moving parts. Among the particle properties he cited particle shape and size as the most important. The bad effects of density differences are not as marked when the particles are small and closely sized. Moisture content, friability, angle of repose and flowability were also mentioned to influence the rate of mixing.

Pellet production is one of the most important processes in a modern feed mill. Robinson (20) stated that an adequate, well regulated supply of steam is a must for any efficient pelleting operation. As a general rule 5% steam addition is accepted as a maximum though in some cases this may be exceeded.

Shulman and Pfost (21) studied the problems in removing the pellet moisture added by steam in high humidity areas. They found that the relative humidity of the air and pellet diameter were the two major factors affecting pellet drying and therefore in high relative humidity areas it would almost be impossible to dry feed pellets of more than $\frac{1}{4}$ " in diameter to satisfactory storage moisture levels by using ambient air. To overcome these problems, they proposed the use of hot air and developed a pellet drying equation to apply to those cases.

Headley (22) studied the effect of various environment temperatures and relative humidities on pelleted feeds with respect

to moisture content, pellet durability and mold formation. The equilibrium moisture contents of a group of different feed pellets and feedstuffs were determined. He found that pelleted complete feed and high urea supplements attained significantly higher equilibrium moisture contents than intact cereal grains, except for materials high in fiber such as dehydrated alfalfa pellets and pelleted materials with surface coatings of animal fat.

METHODS

The data used in this work was collected by the Kansas State University Feed Mill throughout the years 1962 to 1969. The outgoing feeds were sampled by taking grab samples during sack-off and retaining a 4 oz. sample for each code number made each day. After the samples were ground to pass a sieve with a circular opening 1/25" (1 mm.) diameter, they were thoroughly mixed and analyzed. A duplicate analysis of each sample was performed and the results averaged. All the analyses (moisture, protein, fat, fiber, ash) were performed following the methods and procedures of the A.O.A.C. (23).

This report is based on four feed rations on which more data covering the longest possible period of time was available. The rations chosen were: one crumblized chick grower, one crumblized chick starter, one complete layer mash and one pelleted pig grower. These rations were identified as P-17, P-18, P-23 and S-35G, respectively. The data was collected and summarized from Kansas State University Feed Mill Quality Control

files and ordered by month, quarter and year.

The average and range in values of moisture, protein, fat, fiber and ash for all formulas was calculated for each month, quarter and year. Assuming that the values were uniformly distributed, the standard deviation was calculated for each year and quarter in all formulas. The monthly standard deviations were calculated only for P-17 and P-18 because the number of samples of the other two formulas were inadequate for good estimations.

The monthly and quarterly average, range and standard deviation correspond to all the data available for that particular month and quarter, regardless of the year.

The composition of the four formulas is shown in Table I.

Table I. Composition of Formulations for Quality Control Studies

Ingredients	P-17 %	P-18 %	P-23 %	S-35G %
Soybean meal	14.34	26.28	19.99	19.77
Sorghum grain	24.74	29.87	38.48	76.72
Corn	24.74	29.87	29.98	-
Dehydrated alfalfa meal	4.95	4.98	2.50	-
Oats	9.90	-	-	-
Wheat Middlings	9.90	-	-	-
Fish meal	2.47	2.99	-	-
Meat & Bone meal	4.95	-	-	-
Distillers solubles	-	1.99	-	-
Minerals	2.52	3.04	8.05	2.52
Vitamins, drugs & carrier	0.99	0.99	1.00	0.99

RESULTS AND DISCUSSION

The wet basis percentages of average, range and standard deviation of the four formulas analyzed are summarized in Tables II, III, IV, V and VI; Tables marked (a) cover formulas P-17 and P-18 and Tables marked (b) cover formulas P-23 and S-35G. In the appendix, Figures show the relationship between the percentages of the five proximate analysis components and the years, months and quarters.

MOISTURE: Moisture is one of the most important factors in processing agricultural products. Most storage losses of cereal grains, legumes and hay are caused by insects, mold and heating due to excess moisture. Grain moisture, amount of steam added in pelleting and the air relative humidity and temperature in cooling operations are probably the main factors affecting the moisture of processed feeds. Pellets will leave the pellet mill at temperatures as high as 88°C and as high as 17% moisture content. In the cooling operation the moisture must be reduced to 10 to 12% and the temperature to about 8°C above the ambient temperature (20).

Moisture of the grain is determined by weather pattern and by subsequent drying and storage operations. The results corresponding to moisture are summarized in Table II.

The yearly average moisture levels decreased sharply from 1963 to 1964 and tended to increase since then. The lowest average moisture was in 1964 for all the formulas, as can be

seen in Table II and Figure 1.0. It should be pointed out that the grain used in 1964 was harvested in 1963 and 1964 crop years. Both crop years were below normal. In 1964 sorghum grain production was the smallest since 1956 due to moisture shortages; in Eastern and Central areas late summer rains revived the crop. The late growth tended to delay harvest and the harvest started in late September and was completed in mid November. Corn grain production was also very low; 25% less than in 1963 and 32% less than average. The harvest was virtually completed in November (24).

It is possible to observe in Figure 1.1 that the P-23 moisture was affected as much as the others in 1964 and also followed similar patterns in the other years. Since the other formulas were crumblized or pelleted and P-23 was a mash formula, this indicates the importance of grain moisture rather than the factor of moisture addition associated with the pelleting operation. Early harvesting to minimize feed losses and to increase grain crop production could be the cause for moisture increase in recent years. Higher grain moisture levels may have resulted because the grain elevators may have not been fully prepared to handle large amounts of high moisture grain.

The standard deviation was highest in 1964 for P-17 and S-35G, in 1965 for P-18 and in 1967 for P-23 (Table II).

Monthly averages tend to be higher in May and June (Table II). Summarized moisture data is given in Figure 1.0 by years and Figure 1.1 by quarters. Shown in Figures 1.2 and 1.3 for P-17 is the standard deviation and average values by year and month showing the range covered by + or - one standard deviation.

Table II (a)

M o i s t u r e

PERIOD	P-17			P-18						
	n	Mean	Range	S	n	Mean	Range	S		
January	14	10.34	12.8 -	7.1	1.8126	4	9.90	13.2 -	6.2	2.9597
February	12	10.34	12.2 -	8.1	1.4062	6	11.08	12.6 -	10.4	0.9349
March	13	10.62	12.7 -	6.8	1.7944	9	10.95	12.5 -	8.0	1.5906
April	11	10.54	13.0 -	7.9	1.8338	7	10.78	13.7 -	7.8	2.2064
May	13	11.36	13.3 -	9.7	0.8646	9	11.58	12.1 -	10.0	0.6595
June	14	10.74	12.1 -	4.8	1.8215	11	11.75	12.2 -	11.2	0.3362
July	16	10.95	12.1 -	10.1	1.2144	5	11.02	12.1 -	9.0	1.1990
August	18	10.88	11.7 -	9.9	0.5785	-	-	-	-	-
September	17	10.88	12.1 -	8.8	0.8934	1	11.50	-	-	-
October	14	10.71	12.1 -	8.8	0.9934	4	9.75	11.6 -	8.5	1.3178
November	1	11.50	-	-	-	4	10.50	11.8 -	9.5	0.9966
December	2	11.05	11.8 -	10.3	1.0630	4	11.65	12.9 -	8.8	1.9227
Quarter 1	50	10.45	13.0 -	6.8	1.6751	26	10.78	13.7 -	6.2	1.8334
" 2	61	10.97	13.3 -	4.8	1.1749	25	11.54	12.2 -	9.0	0.7136
" 3	34	10.84	12.1 -	8.8	0.9132	13	10.70	12.9 -	8.5	1.5083
Yr. 1962	9	10.93	12.1 -	9.9	0.7984	-	-	-	-	-
" 1963	17	10.46	11.3 -	8.9	0.8407	10	10.52	12.1 -	7.8	1.4591
" 1964	22	8.62	10.7 -	4.8	1.3481	12	9.34	10.5 -	8.0	0.7550
" 1965	33	10.98	13.3 -	8.1	1.1853	10	11.25	13.1 -	6.2	1.9382
" 1966	11	10.93	11.7 -	9.7	0.5692	5	10.74	11.2 -	10.3	0.3571
" 1967	20	11.38	12.1 -	10.6	0.4237	13	11.88	12.7 -	11.5	0.3000
" 1968	22	11.41	12.3 -	10.5	0.4967	14	12.13	13.7 -	10.7	0.7889
" 1969	11	12.11	12.8 -	11.4	0.4806	-	-	-	-	-
Total	145	10.76	13.3 -	4.8	1.3317	64	11.06	13.7 -	6.2	1.4539

Table II (b) M o i s t u r e

PERIOD	P-23			S-35G					
	n	Mean	Range	S	n	Mean	Range	S	
January	3	10.70	11.7 -	9.2	-	3	12.63	14.6 - 10.4	-
February	5	11.06	11.9 -	10.3	-	3	12.80	14.4 - 10.0	-
March	3	11.17	12.5 -	10.4	-	1	8.70	-	-
April	2	11.20	11.4 -	11.0	-	2	13.25	13.6 - 12.9	-
May	4	13.12	16.8 -	11.6	-	-	-	-	-
June	1	11.50	-	-	-	2	12.05	12.7 - 11.4	-
July	4	11.22	11.3 -	11.1	-	3	12.10	12.7 - 11.1	-
August	2	11.00	11.7 -	10.3	-	3	12.10	12.4 - 11.5	-
September	-	-	-	-	-	3	12.30	12.5 - 12.2	-
October	2	9.85	10.7 -	9.0	-	5	12.76	13.0 - 12.3	-
November	3	10.57	12.4 -	8.0	-	2	12.85	13.5 - 12.2	-
December	2	11.60	12.3 -	10.9	-	2	10.90	14.3 - 7.5	-
Quarter 1	13	11.02	12.5 -	9.2	0.8534	9	12.39	14.6 - 10.0	2.1445
" 2	11	11.90	16.8 -	10.3	1.6994	8	12.09	12.7 - 11.1	0.6447
" 3	7	10.66	12.4 -	8.0	1.6340	12	12.35	14.3 - 7.5	1.6501
Yr. 1962	-	-	-	-	-	-	-	-	-
" 1963	-	-	-	-	-	1	7.50	-	-
" 1964	2	8.50	9.0 -	8.0	0.7071	4	10.12	11.4 - 8.7	1.1180
" 1965	3	10.37	11.6 -	9.2	1.2021	-	-	-	-
" 1966	4	10.65	11.4 -	10.3	0.5066	2	12.40	12.5 - 12.3	0.1414
" 1967	10	11.87	16.8 -	10.6	1.7114	16	12.57	14.3 - 11.1	0.7371
" 1968	8	11.61	12.4 -	10.7	0.6665	6	13.73	14.6 - 12.9	0.7307
" 1969	4	11.62	12.5 -	10.9	0.7188	-	-	-	-
Total	31	11.25	16.8 -	8.0	1.4308	29	12.29	14.6 - 7.50	1.5824

Monthly standard deviation was higher in April for P-17 and P-18. For the other formulas it was not calculated due to lack of data.

Average moisture was lower in the second quarter for formula S-35G and higher for the other three formulas (Table II and Figure 1.1). The reason for the lower value is lack of values for S-35G in May.

The standard deviation was higher in the first quarter for P-17, P-18 and S-35G and in the second quarter for P-23 (Table II).

PROTEIN: Protein has two major effects in feed manufacturing. It is nutritionally important since proteins are indispensable in a diet for animal growth and body performance and it has an economical importance since proteins are expensive and therefore should be fed only in amounts that insure good animal performance.

Protein averages, range and standard deviations are summarized in Table III (WB). Trends in average protein levels are given in Figure 2.0 and Figure 2.1. Discussion covers data on an "as is" or wet basis (WB) and on an adjusted dry basis (DB).

Average protein found from all the samples analyzed was higher than the average calculated using ingredient averages found in tables, for P-17, P-18 and P-23, and lower for S-35G.

Variation in average protein through the years 1962 to

1969 had been small for formulas P-17 and P-18 (Figure 2.0). The differences between maximum and minimum values were 0.90% WB (1.07% DB), 1.35% WB (1.43% DB) and 2.80% WB (3.35% DB) for P-17, P-18 and P-23 respectively (Table III). The variations for P-23 and S-35G were expected to be larger since the number of sources of protein were less than those for P-17 and P-18. Therefore they would be more affected by ingredient variation.

Standard deviation (Table III) was highest in 1969 for P-17 and P-23, but this is meaningless because 1969 values correspond only to the first three months of the year and these were high. Probably the most significant highest standard deviations were 1963 for P-17 (Figure 2.2) and 1965 for P-18 and P-23.

The highest standard deviation for P-17 occurred in March and in May and November for P-18. The standard deviation for P-17 was high in the first four months of the year and in July (Figure 2.3); this pattern was not followed by P-18.

April and February were the most representative of higher than average monthly values for P-17 and P-23. For the other formulas the higher than average monthly values were not consistently high in the individual years.

Formulas P-17 and P-23 had the highest average protein (Figure 2.1) and the highest standard deviation (Table III) in the first quarter of the year. P-18 and S-35G had the highest average protein in the second quarter and the highest standard deviation in the third quarter. The limits (average $\pm$ standard deviation) between which the 68% of the P-17 sample values fell

Table III (a) P r o t e i n

PERIOD	P-17			S	P-18			S
	n	Mean	Range		n	Mean	Range	
January	14	20.04	22.3 - 18.3	1.0873	4	21.17	21.6 - 20.5	0.4796
February	12	20.01	23.2 - 18.4	1.3277	6	21.12	21.8 - 20.6	0.4879
March	13	19.57	23.8 - 17.2	1.5634	9	21.43	22.4 - 19.6	0.9381
April	11	20.36	22.8 - 18.7	1.0700	7	20.47	21.6 - 19.5	0.9478
May	13	19.59	21.0 - 18.0	0.7136	9	21.64	27.5 - 20.0	2.2611
June	14	19.30	20.7 - 16.8	0.8255	11	21.26	24.0 - 19.4	1.1623
July	16	19.18	20.6 - 15.2	1.2439	5	20.74	21.7 - 19.8	0.6910
August	18	19.30	20.5 - 18.0	0.7038	-	-	-	-
September	17	19.32	20.2 - 18.0	0.6906	1	22.50	-	-
October	14	19.27	19.9 - 18.6	0.4085	4	19.95	21.3 - 17.4	1.7748
November	1	19.50	-	-	4	20.45	22.7 - 17.5	2.1749
December	2	19.10	19.5 - 18.7	0.5657	4	21.65	22.7 - 21.0	0.7853
Quarter 1	50	19.98	23.8 - 17.2	1.2729	26	21.06	22.4 - 19.5	0.8499
" 2	61	19.33	21.0 - 15.2	0.8932	25	21.30	27.5 - 19.4	1.5675
" 3	34	19.29	20.2 - 18.0	0.5573	13	20.82	22.7 - 17.4	1.6990
Yr. 1962	9	19.66	20.3 - 19.5	0.6294	-	-	-	-
" 1963	17	19.16	21.2 - 15.2	1.4703	10	21.10	24.0 - 17.4	1.7003
" 1964	22	20.00	23.8 - 18.7	1.1256	12	21.29	22.7 - 20.0	0.7658
" 1965	33	19.89	22.8 - 18.3	0.8197	10	21.99	27.5 - 19.6	2.1058
" 1966	11	19.10	20.0 - 18.4	0.5762	5	20.86	21.4 - 20.6	0.3122
" 1967	20	19.32	20.3 - 18.0	0.6215	13	20.85	22.5 - 17.5	1.3216
" 1968	22	19.15	20.2 - 18.0	0.6369	14	20.64	22.7 - 19.4	0.8736
" 1969	11	19.76	23.2 - 17.2	1.6908	-	-	-	-
Total	145	19.55	23.8 - 15.2	1.0272	64	21.10	27.5 - 17.4	1.3432

Table III (b) P r o t e i n

PERIOD	P-23				S-35G			
	n	Mean	Range	S	n	Mean	Range	S
January	3	17.00	17.9 - 15.9	-	3	16.80	18.2 - 16.1	-
February	5	18.78	23.9 - 16.8	-	3	15.53	16.1 - 14.4	-
March	3	16.60	17.7 - 15.4	-	1	16.60	-	-
April	2	15.60	16.0 - 15.2	-	2	16.20	16.8 - 15.6	-
May	4	16.37	17.7 - 15.5	-	-	-	-	-
June	1	15.90	-	-	2	16.65	17.4 - 15.9	-
July	4	16.95	18.1 - 16.2	-	3	16.70	17.2 - 16.4	-
August	2	14.55	15.1 - 14.0	-	3	17.03	17.7 - 16.5	-
September	-	-	-	-	3	16.67	17.5 - 16.2	-
October	2	16.95	17.5 - 16.4	-	5	16.32	17.1 - 15.4	-
November	3	17.00	17.6 - 16.1	-	2	14.55	15.1 - 14.0	-
December	2	16.40	16.5 - 16.3	-	2	16.90	17.8 - 16.0	-
Quarter 1	13	17.38	23.9 - 15.2	2.2200	9	16.22	18.2 - 14.4	1.0099
" 2	11	16.21	17.7 - 14.0	1.1520	8	16.81	17.7 - 15.9	0.5964
" 3	7	16.81	17.6 - 16.1	0.6285	12	16.21	17.8 - 14.0	1.0449
Yr. 1962	-	-	-	-	-	-	-	-
" 1963	-	-	-	-	1	17.80	-	-
" 1964	2	17.55	17.6 - 17.1	0.1000	4	17.07	18.2 - 16.1	0.9219
" 1965	3	16.90	17.9 - 15.1	1.5620	-	-	-	-
" 1966	4	16.05	16.8 - 15.2	0.8699	2	16.40	16.6 - 16.2	0.2828
" 1967	10	16.55	17.7 - 15.5	0.7535	16	16.31	17.7 - 14.0	0.9359
" 1968	8	16.37	18.1 - 14.0	1.1699	6	15.85	16.8 - 14.4	0.8075
" 1969	4	18.85	23.9 - 15.9	3.5977	-	-	-	-
Total	31	16.84	23.9 - 14.0	1.6624	29	16.38	18.2 - 14.0	0.9398

are shown in Figures 2.2 and 2.3. Figure 2.2 shows the overall and yearly average and limits, and Figure 2.3 shows the overall and monthly average and limits.

The overall coefficient of variation was highest for P-23 followed by P-18 and lowest for P-17. Since P-23 and P-18 have higher proportion of corn than the other formulas, this may suggest wider variation in corn protein.

It is important to note that the mean values for formula P-17 had been well above of 16% suggested for chick growers and only one value of the 145 samples analyzed fell below 16%. On the other hand the 1968 mean value for S-35G fell slightly below (15.85%) the 16% pig grower requirements. The 1968 average, however, was calculated from only six samples.

FAT: Fats are concentrated sources of energy, cut down on dustiness and also serve as important sources of essential fatty acids and for the transport of fat soluble vitamins.

Fat averages, ranges and standard deviations can be seen in Table IV.

Yearly average for formulas P-17 and P-23 followed an opposite pattern, as can be seen in Figure 3.0. For P-17 the highest mean value was in 1965 and the lowest in 1966; for P-23 the highest mean value was in 1966 and the lowest in 1965. April had the lowest mean value for P-17 and the highest for P-23. Since corn supplied about 40% of the fat in P-23 and only about 28% in P-17, it could be possible that corn fat variations had some influence on these results. Probably the lowest fat

F a t

Table IV (a)

PERIOD	P-17				P-18			
	n	Mean	Range	S	n	Mean	Range	S
January	14	3.74	4.40 - 3.00	0.4376	4	3.00	3.20 - 2.90	0.1414
February	11	3.61	4.40 - 2.60	0.4680	6	2.92	3.14 - 2.50	0.8367
March	13	3.44	4.01 - 2.90	0.2972	9	2.98	3.40 - 2.40	0.3162
April	11	3.37	3.80 - 2.80	0.3256	7	2.89	3.51 - 2.40	0.4359
May	13	3.44	4.00 - 3.10	0.2693	9	3.04	3.60 - 2.60	0.3041
June	14	3.55	4.00 - 2.90	0.3038	11	2.75	3.50 - 1.20	0.5908
July	16	3.57	5.80 - 1.80	0.7916	5	2.94	3.50 - 2.20	0.5268
August	18	3.68	5.30 - 3.20	0.5258	-	-	-	-
September	17	3.56	4.80 - 2.90	0.5012	1	2.20	-	-
October	14	3.76	4.80 - 3.00	0.5136	4	3.00	3.50 - 2.40	0.4546
November	1	3.50	-	-	4	3.10	3.40 - 2.70	0.2944
December	2	3.18	3.40 - 2.96	0.3162	4	3.02	4.10 - 2.60	0.7234
Quarter 1	49	3.55	4.40 - 2.60	0.4043	26	2.94	3.51 - 2.40	0.3085
" 2	61	3.57	5.80 - 1.80	0.5263	25	2.89	3.60 - 1.20	0.4903
" 3	34	3.62	4.80 - 2.90	0.5009	13	2.98	4.10 - 2.40	0.5099
Yr. 1962	9	3.39	3.77 - 2.96	0.2692	-	-	-	-
" 1963	17	3.55	4.01 - 3.00	0.2598	10	3.32	4.10 - 2.90	0.3651
" 1964	21	3.69	4.80 - 2.90	0.6083	12	3.03	3.50 - 2.40	0.4056
" 1965	33	3.74	5.80 - 1.80	0.7115	10	3.01	3.40 - 2.40	0.2728
" 1966	11	3.39	3.60 - 3.10	0.1643	5	2.90	3.10 - 2.40	0.2915
" 1967	20	3.49	3.80 - 3.20	0.1655	13	2.87	3.20 - 2.20	0.3041
" 1968	22	3.46	4.10 - 3.10	0.3093	14	2.57	3.10 - 1.20	0.4532
" 1969	11	3.57	4.40 - 2.60	0.4980	-	-	-	-
Total	144	3.57	5.80 - 1.80	0.4782	64	2.93	4.10 - 1.20	0.4245

Table IV (b)

F a t

PERIOD	P-23			S-35G		
	n	Mean	Range	S	n	Mean
						Range
January	3	2.63	2.8 - 2.5	-	3	2.53
February	5	2.80	3.0 - 2.4	-	2	2.45
March	3	2.80	2.9 - 2.6	-	1	2.90
April	2	3.25	3.7 - 2.8	-	2	2.50
May	4	2.65	3.2 - 2.1	-	-	-
June	1	2.30	-	-	2	2.60
July	4	2.42	2.9 - 2.1	-	3	2.53
August	2	2.85	3.0 - 2.7	-	3	2.53
September	-	-	-	-	3	2.80
October	2	3.05	3.1 - 3.0	-	5	2.58
November	3	2.60	2.6 - 2.6	-	2	2.45
December	2	2.85	3.1 - 2.6	-	2	2.80
Quarter 1	13	2.83	3.7 - 2.4	0.3175	8	2.55
" 2	11	2.57	3.2 - 2.1	0.3821	8	2.55
" 3	7	2.80	3.1 - 2.6	0.2516	12	2.65
Yr. 1962	-	-	-	-	-	-
" 1963	-	-	-	-	1	3.30
" 1964	2	2.85	3.1 - 2.6	0.3606	3	2.93
" 1965	3	2.53	2.8 - 2.1	0.3808	-	-
" 1966	4	2.87	2.9 - 2.8	0.0574	2	2.40
" 1967	10	2.68	3.7 - 2.1	0.4853	16	2.58
" 1968	8	2.77	3.1 - 2.4	0.2563	6	2.40
" 1969	4	2.72	3.0 - 2.4	0.2769	-	-
Total	31	2.73	3.7 - 2.1	0.3410	28	2.59
						3.3 - 2.2
						0.2867

value was in April for P-17.

Yearly and monthly standard deviations were highest in 1965 and July for P-17, in 1968 and February for P-18 and in 1967 for P-23. Shown in Figures 3.2 and 3.3 for P-17 is the standard deviation and average values by year and month showing the range covered by + or - one standard deviation.

The coefficient of variation was the highest for P-18 followed by P-17 and the lowest for S-35G. High fat coefficient of variation in fish meal, distiller solubles and meat and bone meal could be the cause of these high variations.

Formulas P-17 and P-18 had the lowest standard deviations in the first quarter; P-23 in the third quarter and S-35G in the second quarter.

The mean value was higher in the third quarter than in the second for all formulas, as shown in Figure 3.1. This may suggest that some fat is lost during storage.

Mean fat value calculated from all the samples was higher than the average calculated using ingredient averages found in tables, for all formulas.

FIBER: Fiber is not an available source of energy for simple stomach animals; therefore high fiber diets will limit the energy intake and cause poor animal performance.

Fiber averages, ranges and standard deviations can be seen in Table V.

High fiber values occurred in 1963 and 1964 for P-17 and P-18. In 1968 the fiber values of P-17 were also high. For

P-23 the highest value was in 1969 but this value corresponded to only the first three months of 1969. Yearly average data is shown in Figure 4.0.

Standard deviation was highest in 1963 for P-17 and P-18.

The coefficient of variation was the highest in P-17 and the lowest in S-35G. Variations in oat and alfalfa fiber values are probably the principal factor in the high coefficient of variation.

September is probably one of the most representative of high monthly mean values for P-17 because it was more consistent in the individual years.

Standard deviations were relatively high in June for P-17 and P-18. It was also high in August for P-17. The limits (average $\pm$ standard deviation) between which the 68% of the P-17 sample values fell are shown in Figures 4.2 and 4.3. Figure 4.2 shows the overall and yearly average and limits, and Figure 4.3 shows the overall and monthly average and limits.

Mean values were higher than average in the second quarter for all formulas (Table V and Figure 4.1).

Standard deviations were highest in the second quarter for P-17, P-18 and P-23 and the lowest for S-35G.

Since S-35G is the only ration that does not contain alfalfa meal, this could be an indication of the importance of alfalfa in the fiber variation patterns.

F i b e r

Table V (a)

PERIOD	P-17			S	P-18			S
	n	Mean	Range		n	Mean	Range	
January	14	4.71	5.50 - 2.60	0.7580	4	3.82	4.1 - 3.4	0.3416
February	11	4.42	5.70 - 2.40	0.8660	6	3.99	4.8 - 3.3	0.6099
March	13	4.78	5.80 - 3.60	0.5339	9	4.20	5.0 - 3.6	0.4243
April	11	4.48	6.30 - 3.39	0.9695	7	4.19	4.8 - 3.4	0.4916
May	13	5.01	5.80 - 4.30	0.5091	9	4.27	5.7 - 3.3	0.8551
June	14	5.39	7.20 - 4.40	1.0455	11	4.47	5.8 - 3.5	0.7253
July	16	4.74	5.30 - 4.20	0.3327	5	4.28	4.9 - 3.4	0.5635
August	18	5.18	8.10 - 4.10	1.0146	-	-	-	-
September	17	5.27	5.90 - 4.30	0.4485	1	4.30	-	-
October	14	5.18	5.80 - 4.30	0.4641	4	4.02	4.3 - 3.7	0.2516
November	1	5.90	-	-	4	4.07	4.6 - 3.5	0.4796
December	2	4.52	5.50 - 3.54	1.3856	4	4.00	4.4 - 3.6	0.3651
Quarter 1	49	4.61	6.30 - 2.40	0.7757	26	4.09	5.0 - 3.3	0.4741
" 2	61	5.08	8.10 - 4.10	0.8162	25	4.36	5.8 - 3.3	0.7251
" 3	34	5.21	5.90 - 3.54	0.5352	13	4.05	4.6 - 3.5	0.3354
Yr. 1962	9	4.63	5.50 - 3.54	0.5338	-	-	-	-
" 1963	17	5.29	8.10 - 3.39	1.3176	10	4.71	5.8 - 3.72	0.8199
" 1964	21	5.18	7.20 - 4.00	0.8465	12	4.27	5.0 - 3.40	0.3931
" 1965	33	4.56	5.20 - 2.60	0.5793	10	3.93	4.9 - 3.30	0.4830
" 1966	11	5.02	5.50 - 4.40	0.3605	5	3.86	4.8 - 3.40	0.5408
" 1967	20	4.96	5.90 - 3.60	0.5196	13	4.13	4.8 - 3.30	0.4574
" 1968	22	5.25	5.90 - 4.30	0.5052	14	4.10	4.8 - 3.40	0.4914
" 1969	11	4.70	5.70 - 2.40	0.9187	-	-	-	-
Total	144	4.95	8.10 - 2.40	0.7825	64	4.19	5.8 - 3.30	0.5747

F i b e r

Table V (b)

PERIOD	P-23				S-35G			
	n	Mean	Range	S	n	Mean	Range	S
January	3	3.93	4.7 - 3.2	-	3	2.80	3.1 - 2.4	-
February	4	3.77	4.6 - 3.3	-	2	2.80	3.1 - 2.5	-
March	3	3.37	3.8 - 3.1	-	1	2.90	-	-
April	2	3.65	3.7 - 3.6	-	2	2.95	3.3 - 2.6	-
May	4	2.60	3.7 - 3.0	-	-	-	-	-
June	1	3.50	-	-	2	3.10	3.2 - 3.0	-
July	4	3.60	3.8 - 3.4	-	3	3.03	3.1 - 3.0	-
August	2	4.80	5.0 - 4.6	-	3	3.10	3.2 - 3.0	-
September	-	-	-	-	3	2.80	2.8 - 2.8	-
October	2	3.85	4.0 - 3.7	-	5	2.64	3.0 - 2.4	-
November	3	3.40	3.9 - 3.1	-	2	3.30	3.5 - 3.1	-
December	2	3.40	3.4 - 3.4	-	2	2.65	2.9 - 2.4	-
Quarter 1	12	3.69	4.7 - 3.1	0.5161	8	2.85	3.3 - 2.4	0.3206
" 2	11	3.68	5.0 - 3.0	0.6197	8	3.07	3.2 - 3.0	0.0866
" 3	7	3.53	4.0 - 3.1	0.3439	12	2.79	3.5 - 2.4	0.3148
Yr. 1962	-	-	-	-	-	-	-	-
" 1963	-	-	-	-	1	2.40	-	-
" 1964	2	3.40	3.7 - 3.1	0.4243	3	2.83	3.2 - 2.4	0.4062
" 1965	3	3.80	5.0 - 3.2	1.0392	-	-	-	-
" 1966	3	3.67	3.7 - 3.1	0.3082	2	2.75	2.8 - 2.7	0.1000
" 1967	10	3.44	3.9 - 3.0	0.2867	16	2.94	3.5 - 2.4	0.2733
" 1968	8	3.75	4.6 - 3.2	0.4408	6	2.92	3.3 - 2.5	0.3130
" 1969	4	4.20	4.7 - 3.7	0.5228	-	-	-	-
Total	30	3.65	5.0 - 3.0	0.5125	28	2.89	3.5 - 2.4	0.2900

ASH: Ash is the total inorganic fraction of the feed. Frequently the only use of the ash value is that it enables the calculation of carbohydrates by difference. It also can be used as an indication of mixing since distribution of mineral supplements can affect the variation seen in mineral values.

Ash averages, ranges and standard deviations are shown in Table VI.

Mean values were higher in 1962, 1963 and 1964 than in the following years for P-17. The highest mean values were in 1965 for P-18 and P-23. Yearly mean values are shown in Figure 5.0.

The total coefficient of variation was the highest for P-17 and the lowest for S-35G. The high coefficient of variation in P-17 was expected because a large amount of its ash content was supplied by meat and bone meal. Zeigler (8) stated that meat and bone meal is probably the most adulterated and mis-manufactured product on the market and therefore greatest variations in nutritional content due to source and type of manufacture are found. On the other hand the repeated lowest coefficient of variations in S-35G are probably due to the fact that most data for this formula was concentrated in the second half of 1967 and the first months of 1968 and therefore are less affected by year variation.

Monthly mean values were highest in May, June and July for P-17 and in March and July for P-18 (Table VI). These results were not very consistent in the individual years.

The most representative highest standard deviations pro-

bably were May for P-17 and June for P-18. The limits (average $\pm$ standard deviation) between which the 68% of the P-17 sample values fell are shown in Figure 5.2 and Figure 5.3. Figure 5.2 shows the overall and yearly average and limits, and Figure 5.3 shows the overall and monthly average and limits.

Quarterly averages were the highest in the second quarter for P-17, P-18 and P-23 and the lowest for S-35G, as shown in Figure 5.1.

Standard deviations were highest in the first quarter for P-17, P-23 and S-35G and lowest for P-18.

Caution is necessary for interpretation of these ash results because they are probably the most affected by sampling errors due to segregation of the added minerals.

Average ash obtained from all the samples analyzed was lower than the average calculated using ingredient averages found in tables with minerals added.

Table VI (a)

A s h

PERIOD	P-17			S	P-18			S
	n	Mean	Range		n	Mean	Range	
January	14	6.76	7.60 - 4.8	0.6697	4	6.17	6.5 - 6.0	0.2236
February	12	6.91	7.68 - 4.8	0.7954	6	6.05	6.5 - 5.7	0.3286
March	13	6.71	7.57 - 6.2	0.4062	9	6.22	6.6 - 5.6	0.3202
April	11	6.85	7.67 - 6.3	0.4980	7	6.10	6.38 - 5.6	0.2798
May	13	6.97	9.42 - 5.6	0.9069	9	6.09	6.70 - 5.5	0.3708
June	14	6.94	7.90 - 6.1	0.5107	11	6.17	7.1 - 5.3	0.5657
July	16	6.94	7.81 - 5.6	0.5279	5	6.24	6.7 - 5.9	0.3122
August	18	6.87	7.70 - 6.3	0.3804	-	-	-	-
September	17	6.91	7.80 - 6.1	0.5044	1	6.30	-	-
October	14	6.69	7.53 - 6.2	0.3270	4	6.00	6.3 - 5.6	0.3162
November	1	7.00	-	-	4	5.70	6.5 - 4.7	0.7831
December	2	6.57	7.30 - 5.85	1.0247	4	6.02	6.3 - 5.7	0.2769
Quarter 1	50	6.80	7.68 - 4.8	0.5987	26	6.14	6.60 - 5.60	0.2891
" 2	61	6.93	9.42 - 5.6	0.5771	25	6.16	7.10 - 5.30	0.4458
" 3	34	6.80	7.80 - 5.85	0.4612	13	5.94	6.50 - 4.70	0.4804
Yr. 1962	9	7.24	7.81 - 5.85	0.5947	-	-	-	-
" 1963	17	7.36	9.42 - 6.10	0.6777	10	6.22	7.10 - 5.30	0.4761
" 1964	22	7.07	7.90 - 6.10	0.4765	12	5.99	6.40 - 5.50	0.2611
" 1965	33	6.59	7.20 - 4.80	0.4643	10	6.26	7.10 - 5.90	0.3859
" 1966	11	6.62	7.50 - 5.60	0.4796	5	6.20	6.50 - 5.80	0.2915
" 1967	20	6.79	7.40 - 6.20	0.3831	13	5.94	6.50 - 4.70	0.5025
" 1968	22	6.82	7.30 - 6.40	0.3464	14	6.14	6.70 - 5.60	0.3541
" 1969	11	6.53	7.40 - 4.80	0.6678	-	-	-	-
Total	145	6.85	9.42 - 4.80	0.5571	64	6.11	7.10 - 4.70	0.4004

Table VI (b)

A s h

PERIOD	P-23			S-35G		
	n	Mean	Range	n	Mean	Range
January	3	8.33	9.4 - 6.7	3	4.53	4.7 - 4.4
February	4	8.37	9.1 - 7.5	3	4.27	4.4 - 4.1
March	3	8.57	9.1 - 8.2	1	4.60	-
April	2	10.00	10.9 - 9.1	2	4.55	4.8 - 4.3
May	4	8.97	9.4 - 8.6	-	-	-
June	1	8.80	-	2	4.35	4.6 - 4.1
July	4	9.17	9.7 - 8.8	3	4.20	4.3 - 4.0
August	2	10.80	11.4 - 10.2	3	4.33	4.4 - 4.3
September	-	-	-	3	4.50	4.7 - 4.4
October	2	8.95	9.5 - 8.4	5	4.38	4.6 - 4.2
November	3	9.00	9.7 - 8.1	2	4.55	4.8 - 4.3
December	2	8.20	8.4 - 8.0	2	4.30	4.3 - 4.3
Quarter 1	12	8.68	10.9 - 6.7	9	4.46	4.8 - 4.1
" 2	11	9.36	11.4 - 8.6	8	4.29	4.6 - 4.0
" 3	7	8.76	9.7 - 8.0	12	4.42	4.8 - 4.2
Yr. 1962	-	-	-	-	-	-
" 1963	-	-	-	1	4.30	-
" 1964	2	9.35	9.5 - 9.2	4	4.57	4.7 - 4.4
" 1965	3	9.67	10.2 - 9.4	-	-	-
" 1966	3	9.10	9.1 - 9.1	2	4.50	4.6 - 4.4
" 1967	10	9.02	10.9 - 7.9	16	4.34	4.8 - 4.0
" 1968	8	8.96	11.4 - 8.0	6	4.40	4.8 - 4.1
" 1969	4	7.90	9.0 - 6.7	-	-	-
Total	30	8.95	11.4 - 6.7	29	4.40	4.8 - 4.0
			0.7201			0.2007

SUMMARY

The variations in the proximate analysis components of four feed formulas manufactured in the Kansas State feed mills were studied.

The overall moisture coefficient of variation was highest (13.24%) in P-18 formula and lowest (12.38%) in P-17.

The lowest moisture was in 1964 for all formulas. This year was characterized by very low crops due to moisture shortage. An increase of feed moisture in all formulas was observed in recent years.

The overall protein coefficient of variation was highest (9.87%) in P-23 formula and lowest (5.25%) in P-17. Since corn supplied a larger proportion of protein (16.4%) to P-23 than to the other formulas, this may suggest corn protein variation as the cause of such higher variation.

The total fat coefficient of variation was highest (14.5%) in P-18 followed by P-17 (13.4%) and lowest in S-35G (11.07%).

In fiber and ash the highest total coefficient of variation was in P-17 (15.81% and 8.13% respectively) and the lowest in S-35G (10.03% and 4.56% respectively). Variations in oat, alfalfa and wheat middlings values are probably the principal factors in the high fiber variation and meat and bone meal in the high ash variation.

The lowest coefficient of variation in fat, fiber and ash in formula S-35G is probably influenced by the fact that most data for this formula was concentrated in the second half of

1967 and the first months of 1968 and therefore was less affected by year variation.

ACKNOWLEDGMENTS

The writer wishes to express his gratitude to Dr. Charles W. Deyoe, major professor, for his guidance, assistance and encouragement during the research and writing of this manuscript.

For being on the advisory committee and reviewing the manuscript, the writer wishes to thank Dr. Harry B. Pfof and Dr. Teddy O. Hodges.

For the use of the department facilities and for the learning opportunity, appreciation is expressed to Dr. William J. Hoover, Head of the Department of Grain Science and Industry.

Thanks are also extended to other members of the department who gave assistance, especially to Professor Gerald B. Miller.

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APPENDIX

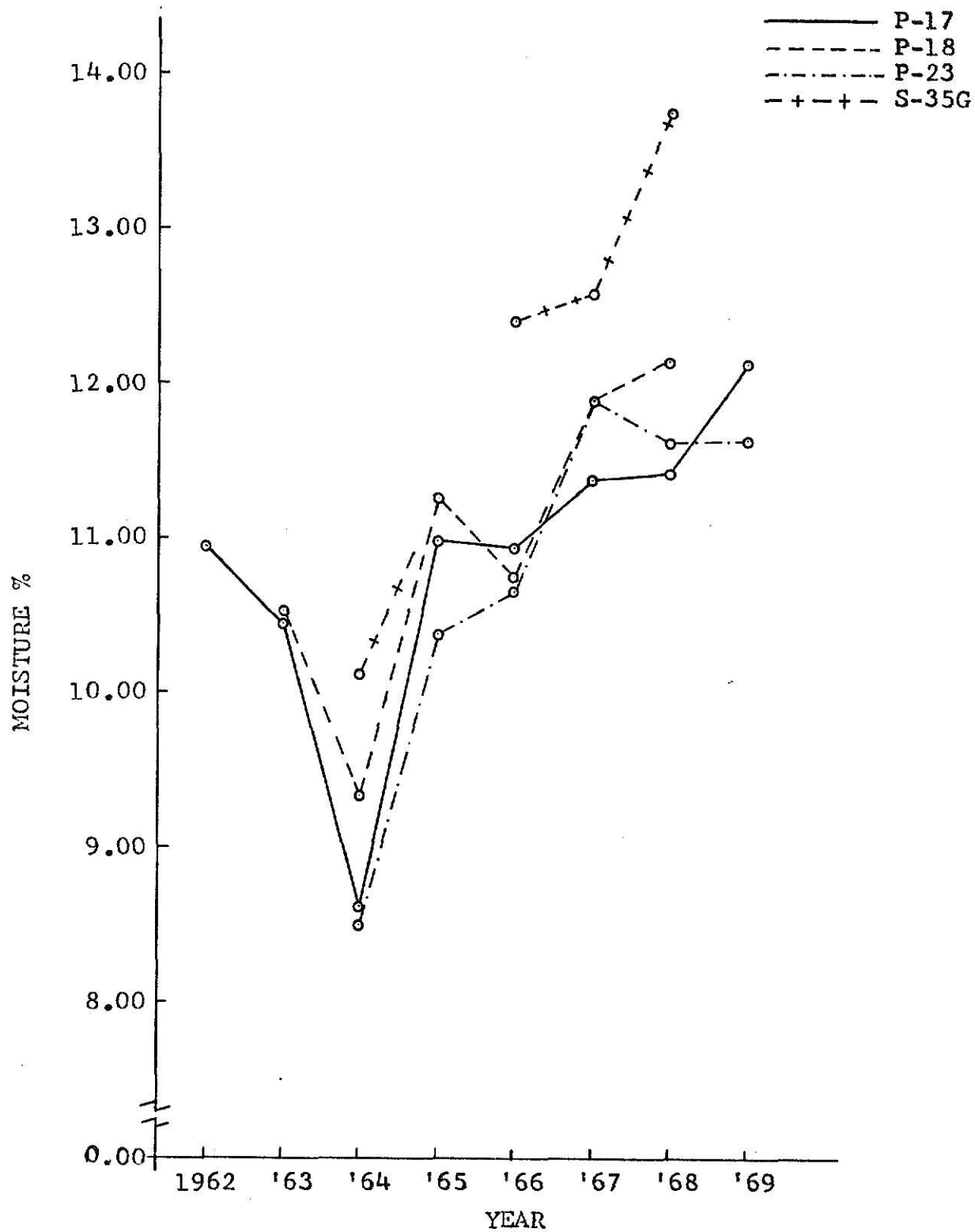


Fig. 1.0 Average Yearly Moisture Levels of Selected Manufactured Feeds

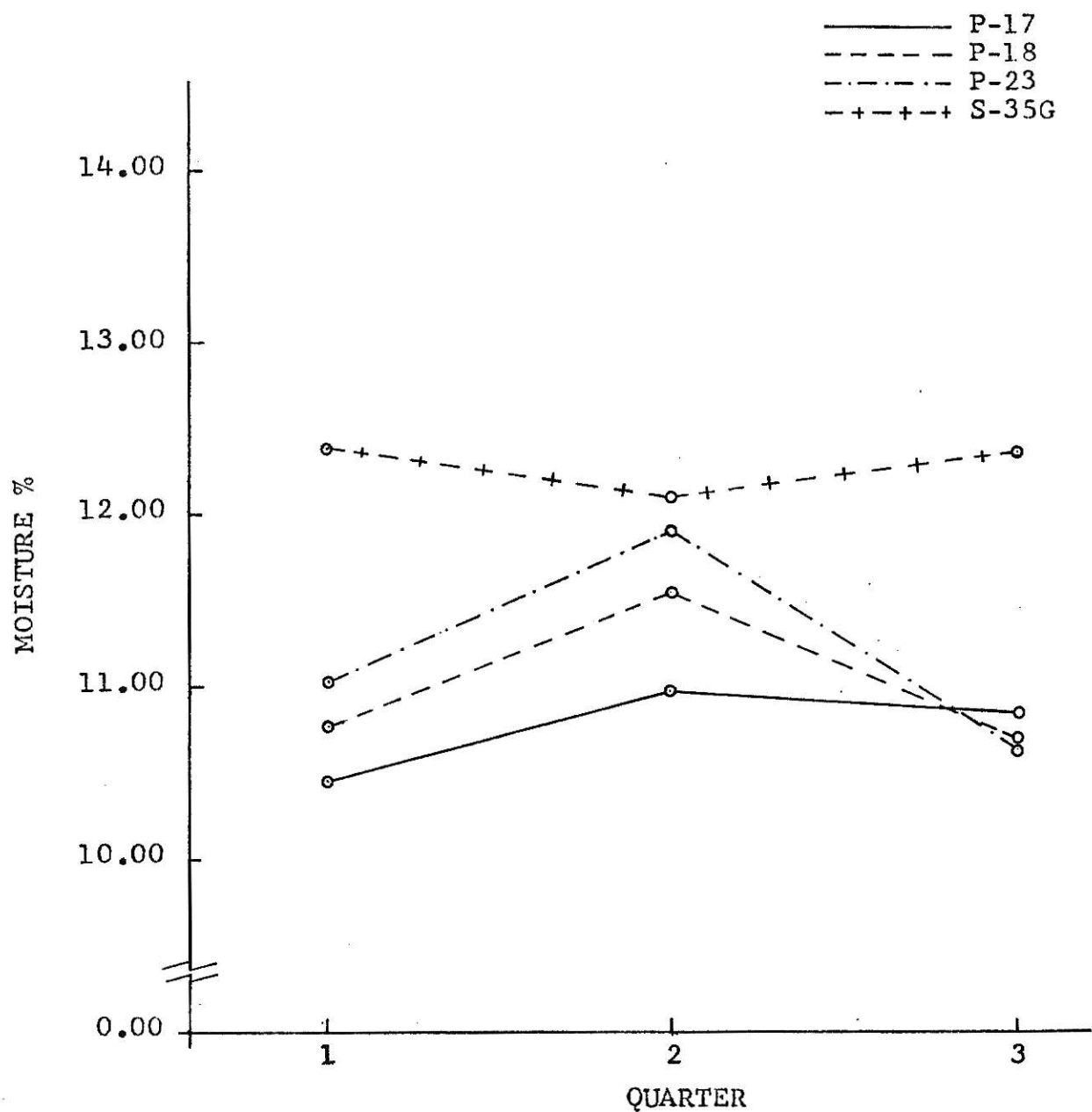


Fig. 1.1 Average Quarterly Moisture Levels of Selected Manufactured Feeds

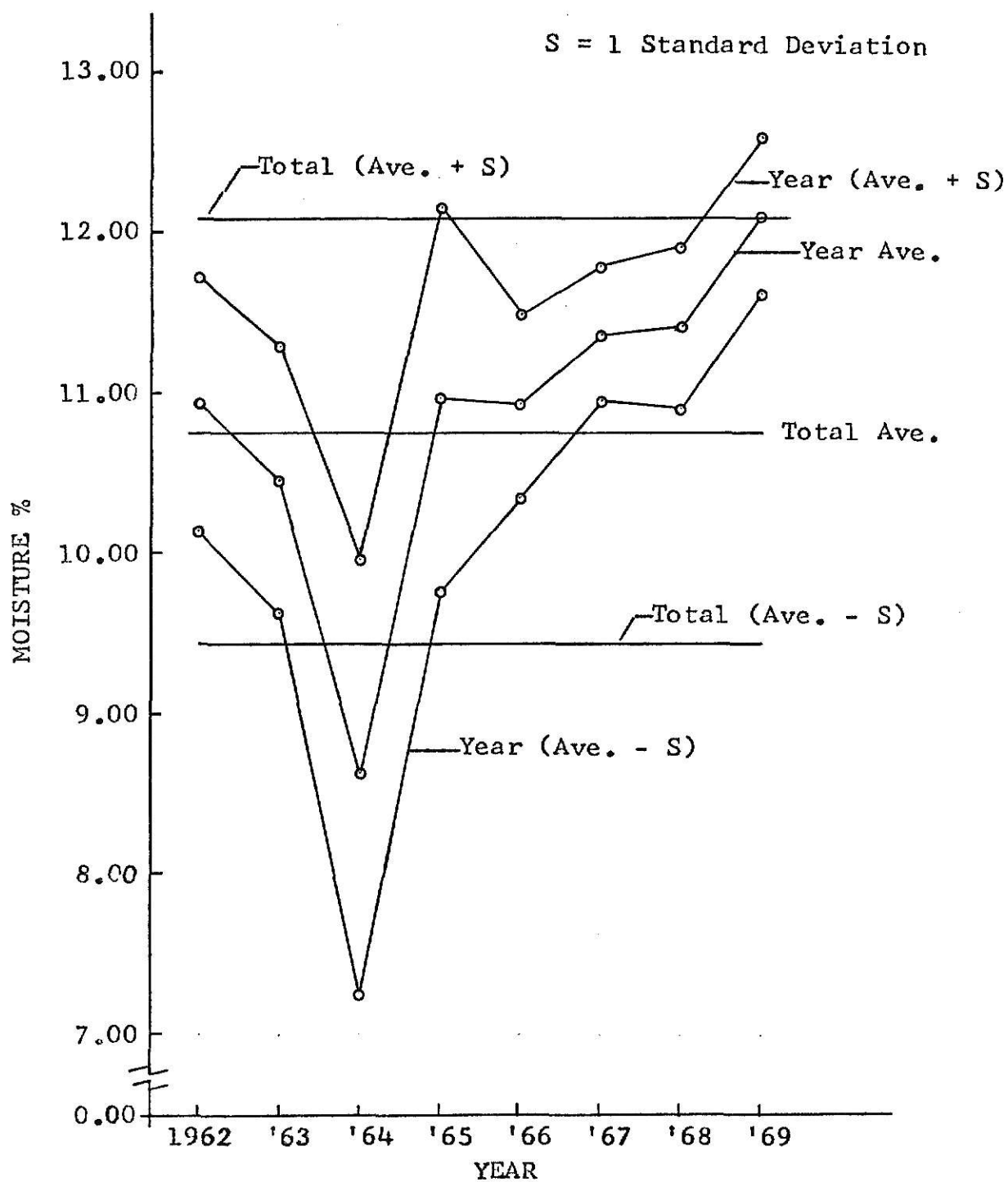


Fig. 1.2 Standard Deviations and Average Moisture Levels of P-17

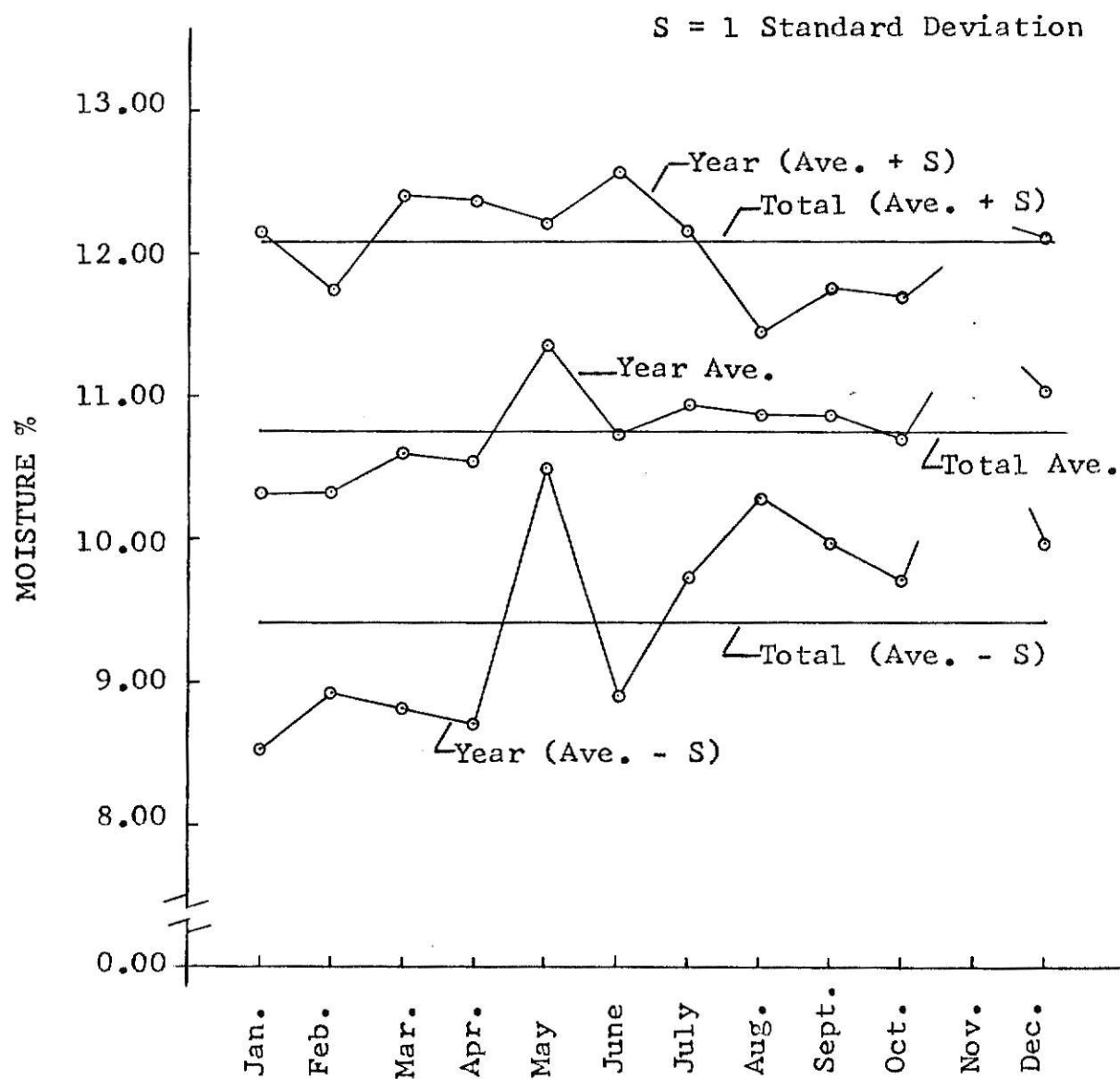


Fig. 1.3 Standard Deviations and Average Moisture Levels of P-17

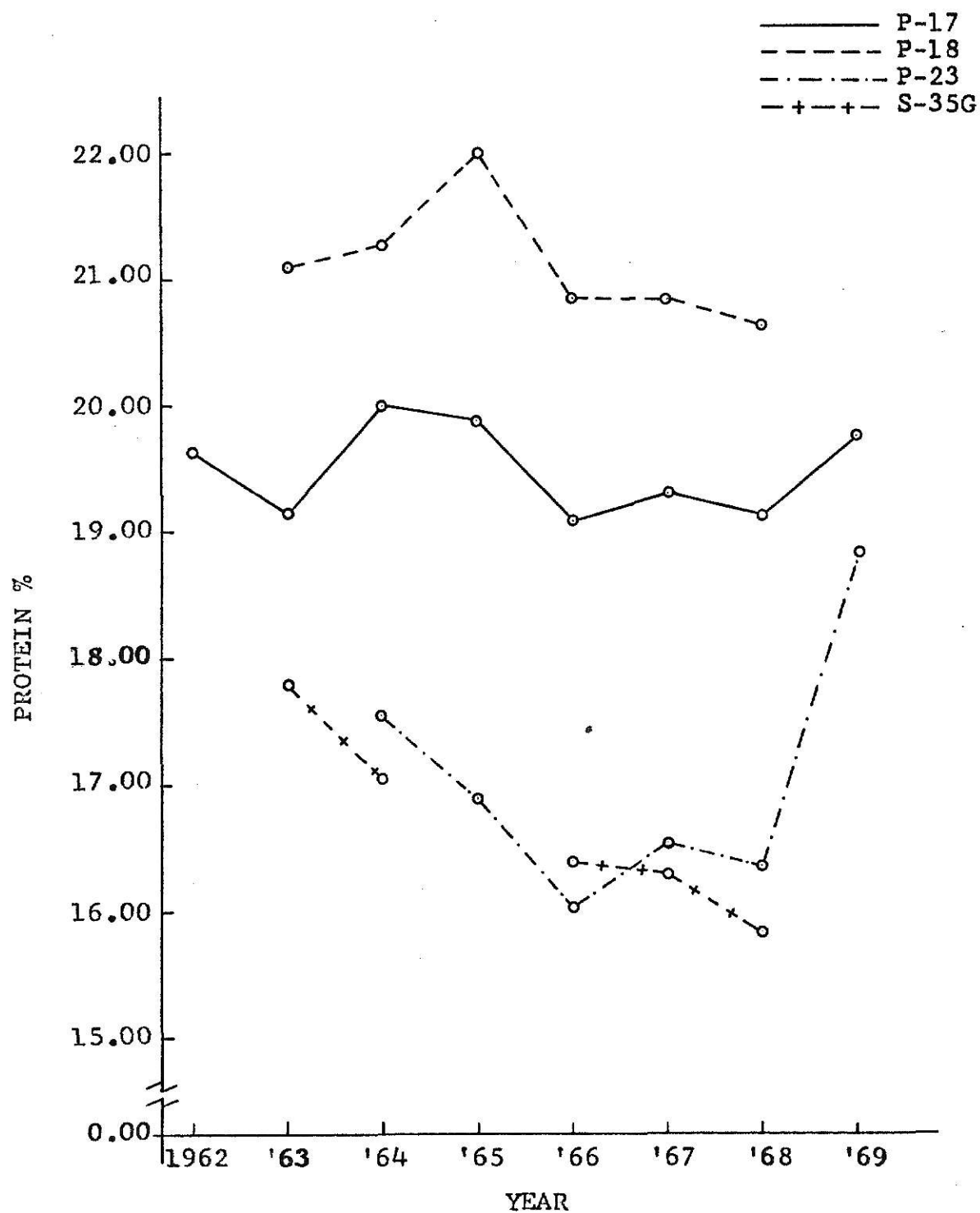


Fig. 2.0 Average Yearly Protein Levels of Selected Manufactured Feeds

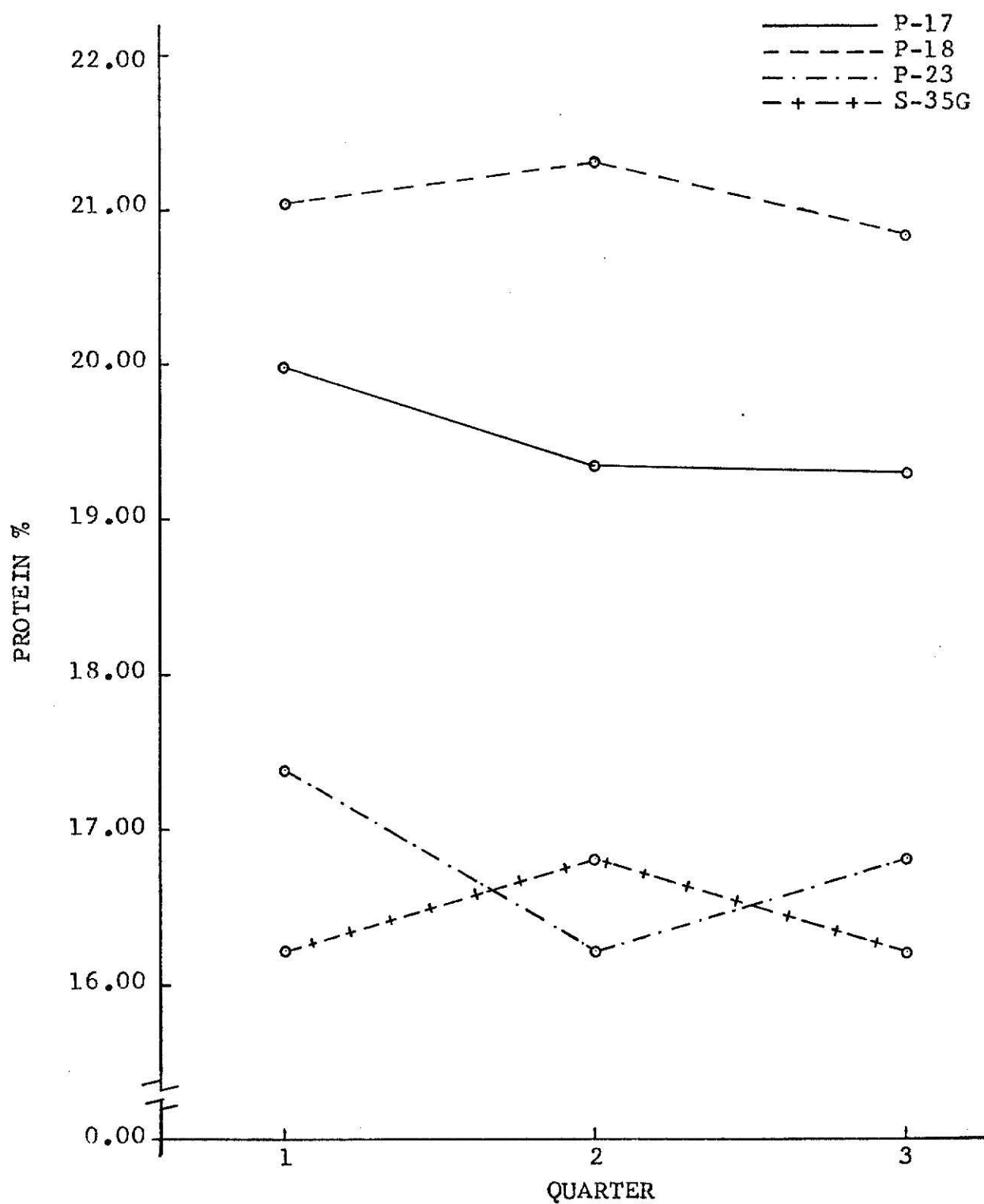


Fig. 2.1 Average Quarterly Protein Levels of Selected Manufactured Feeds.

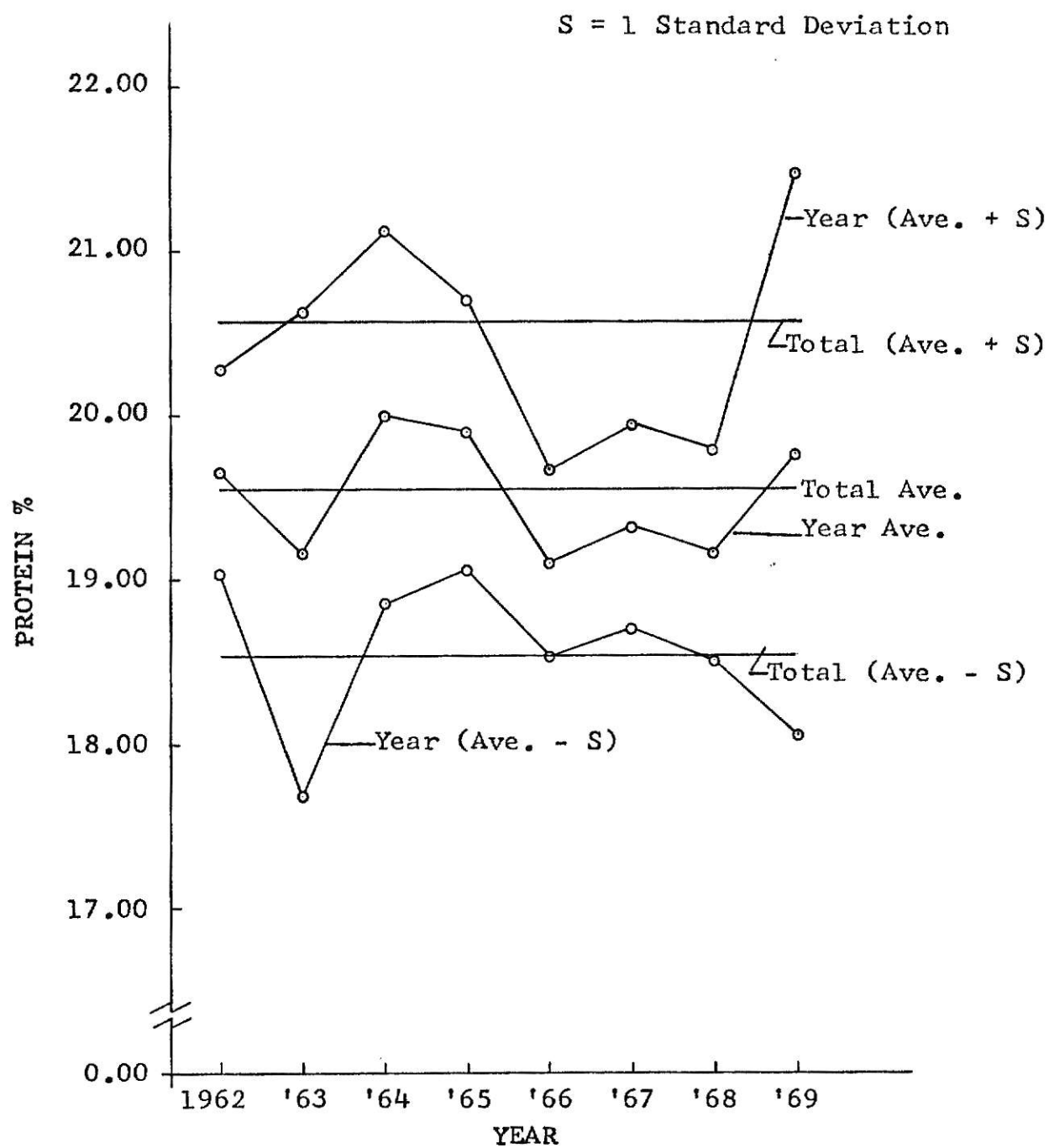


Fig. 2.2 Standard Deviations and Average Protein Levels of P-17

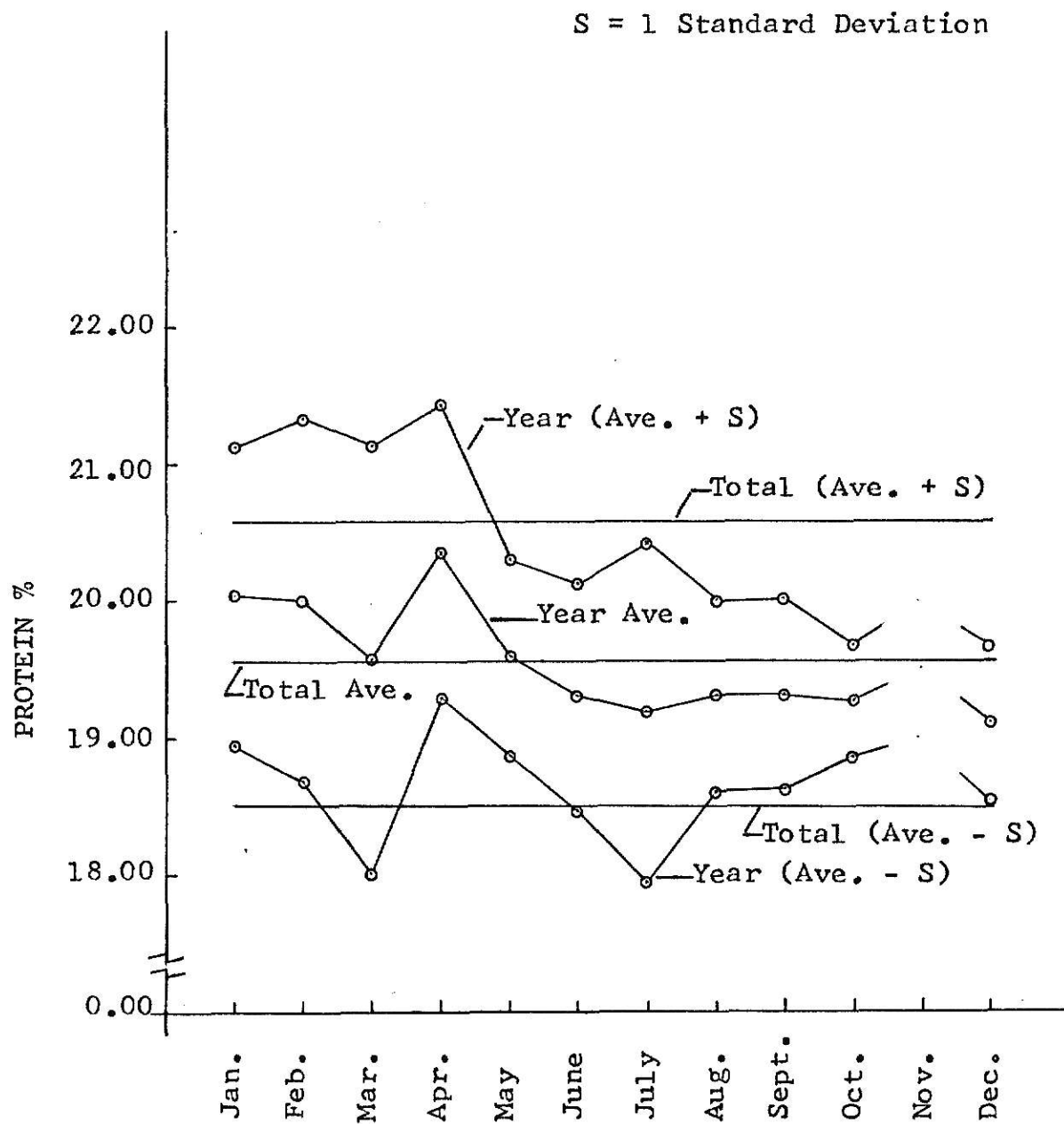


Fig. 2.3 Standard Deviations and Average Protein Levels of P-17

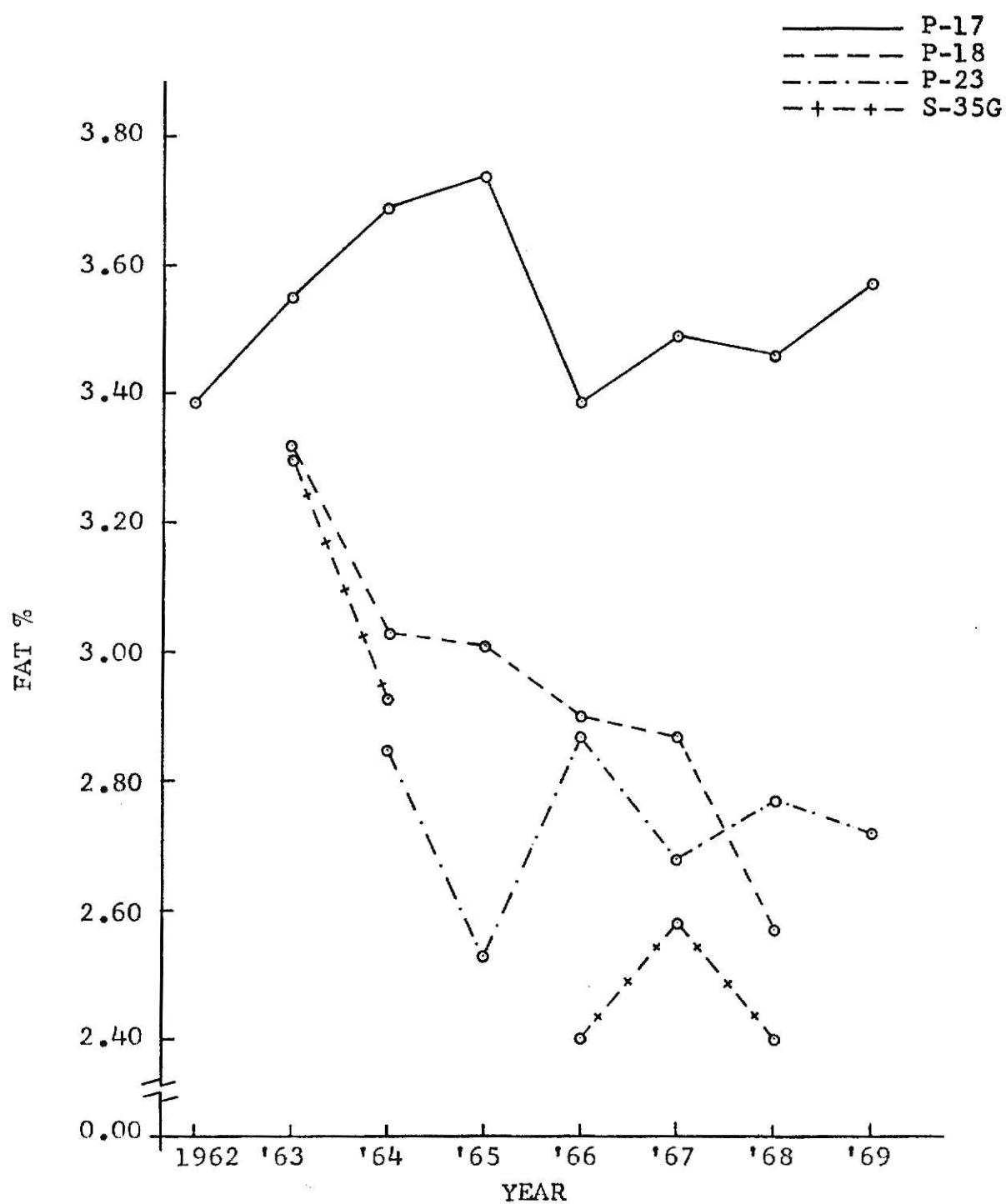


Fig. 3.0 Average Yearly Fat Levels of Selected Manufactured Feeds

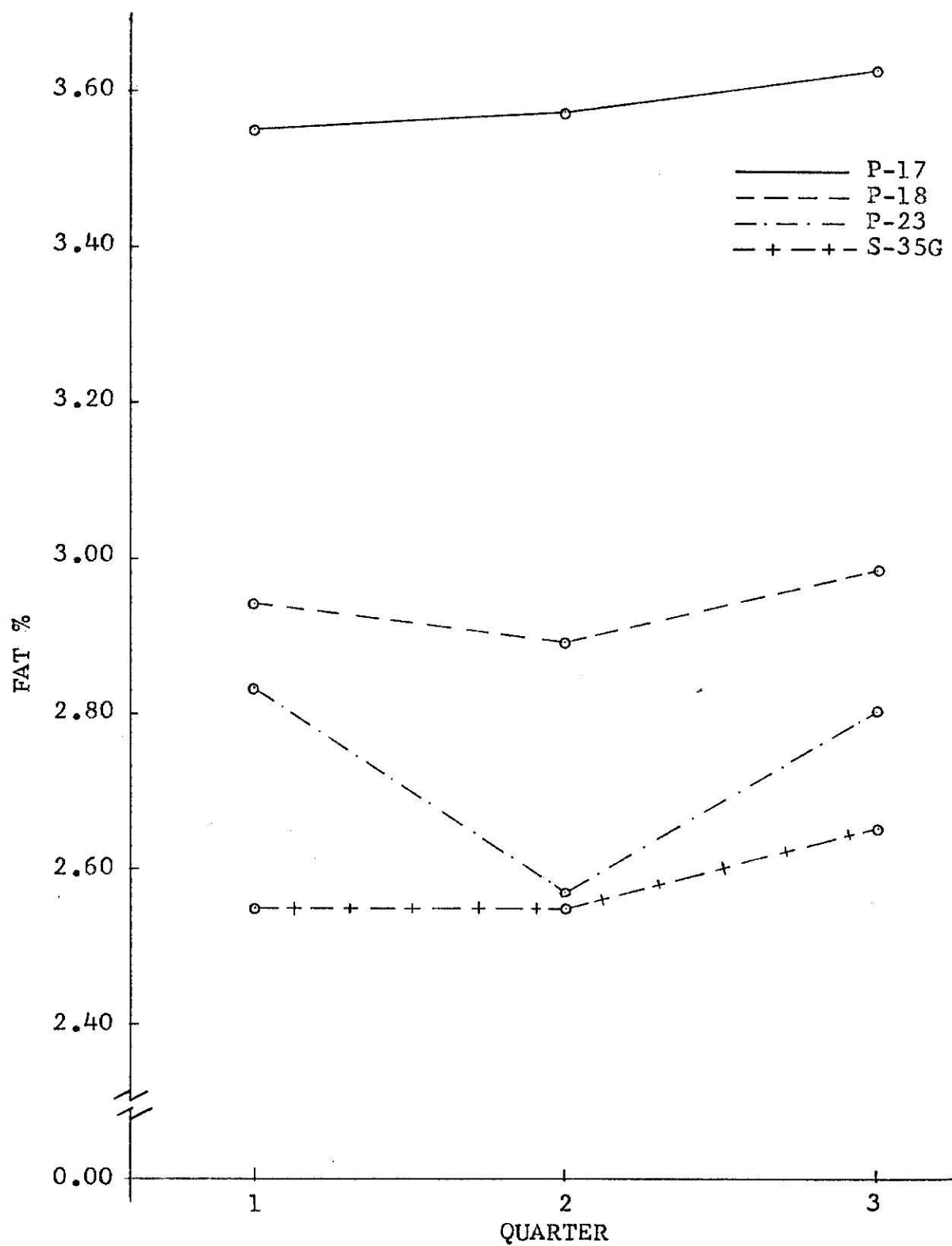


Fig. 3.1 Average Quarterly Fat Levels of Selected Manufactured Feeds

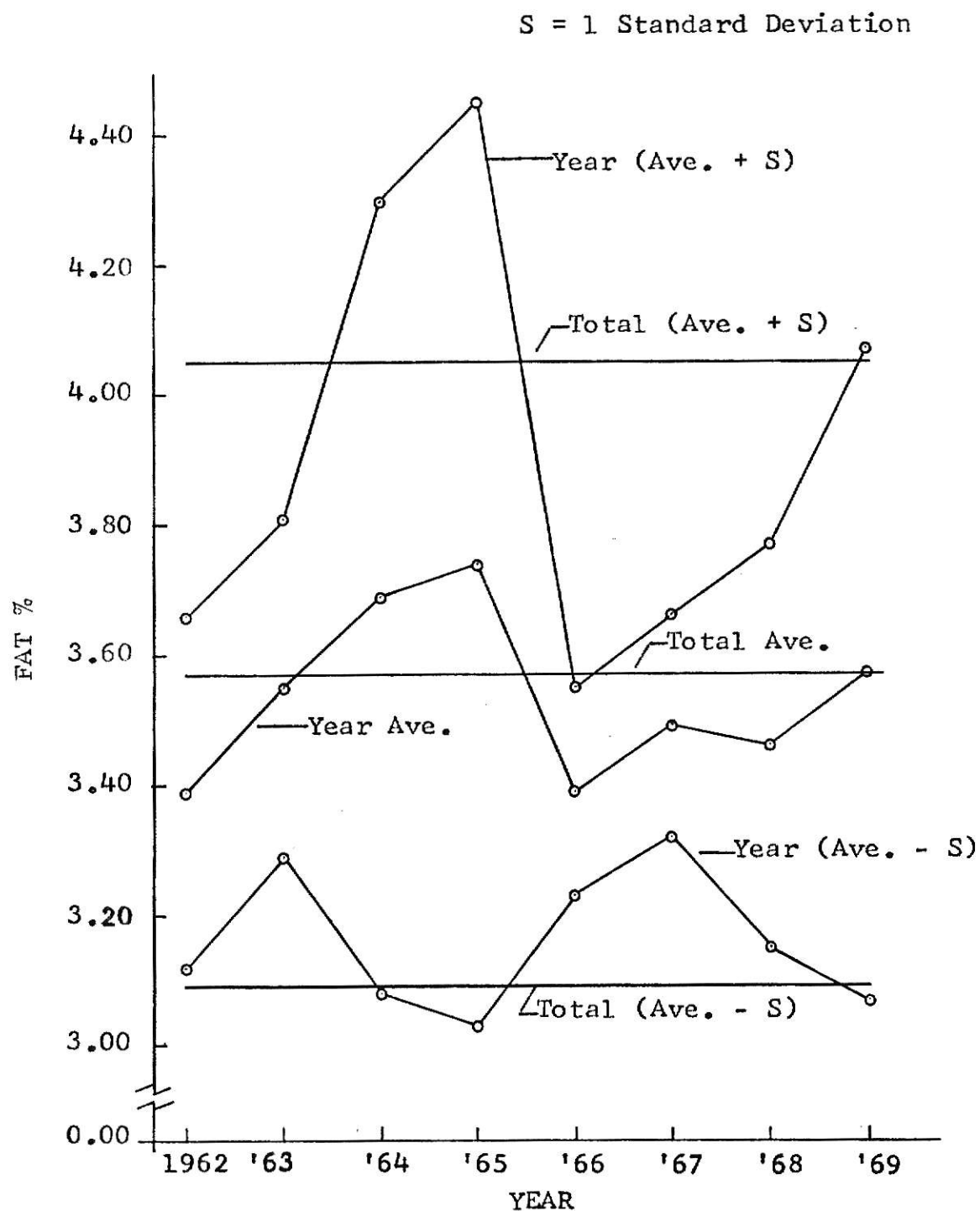


Fig. 3.2 Standard Deviations and Average Fat Levels of P-17

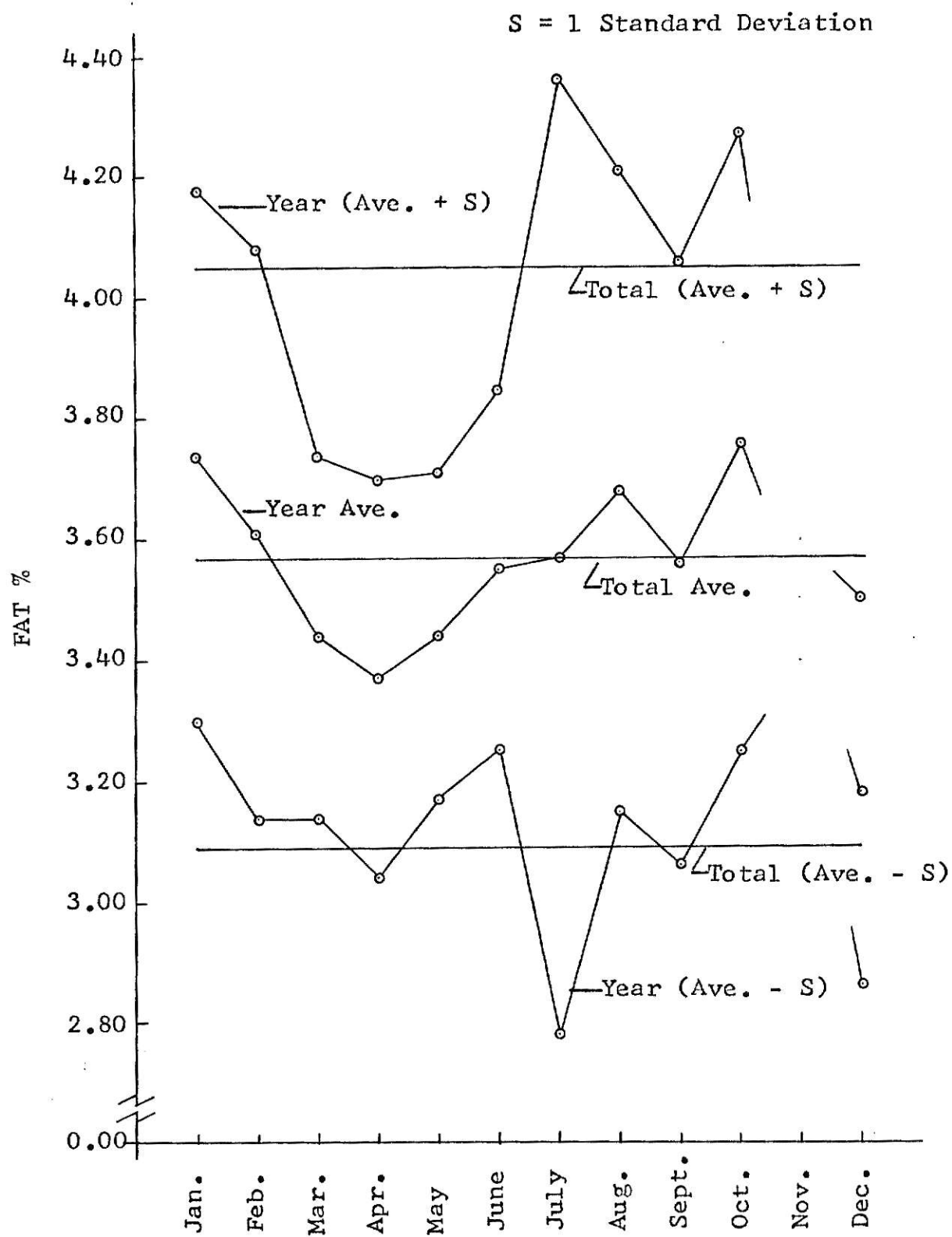


Fig. 3.3 Standard Deviations and Average Fat Levels of P-17

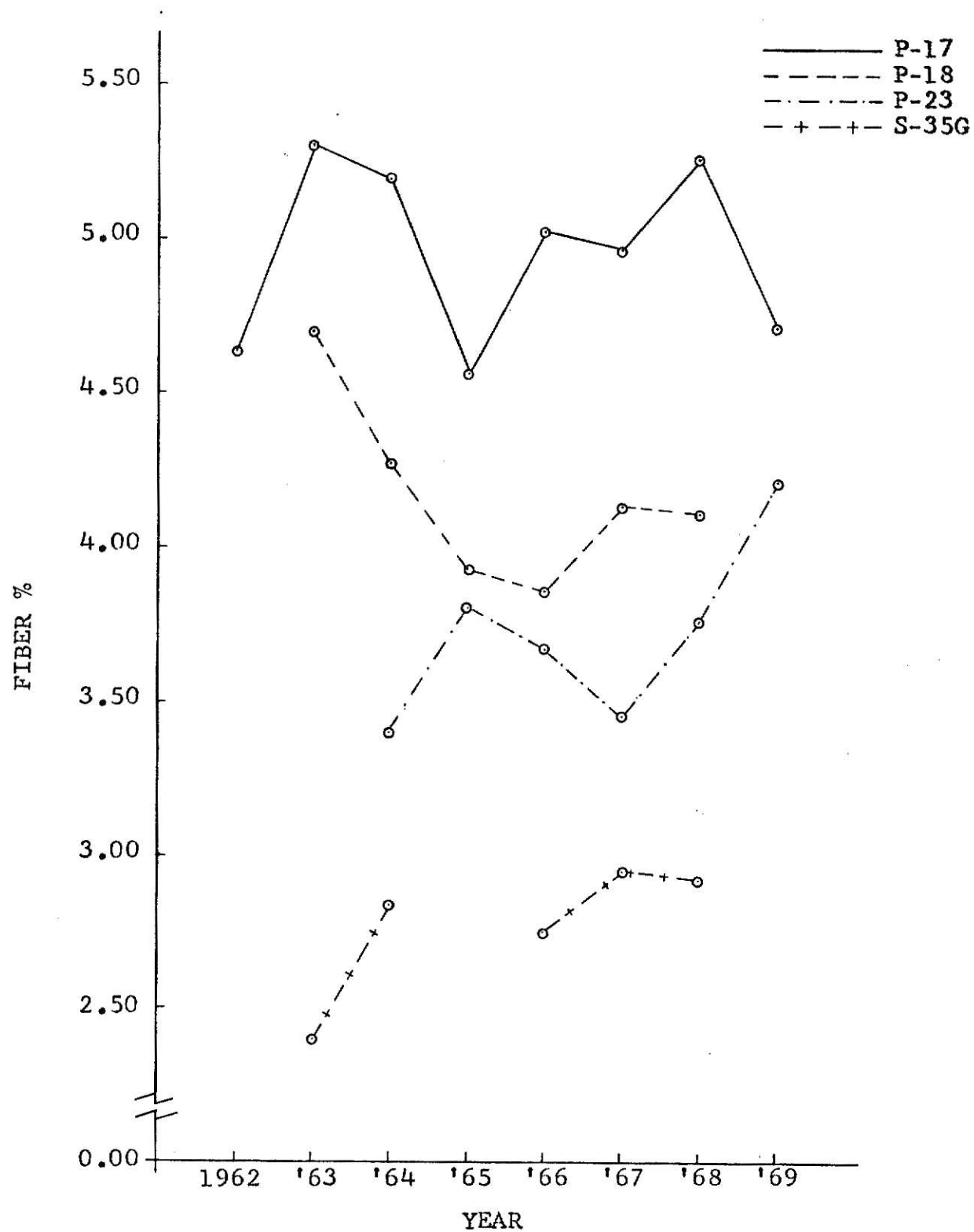


Fig. 4.0 Average Yearly Fiber Levels of Selected Manufactured Feeds

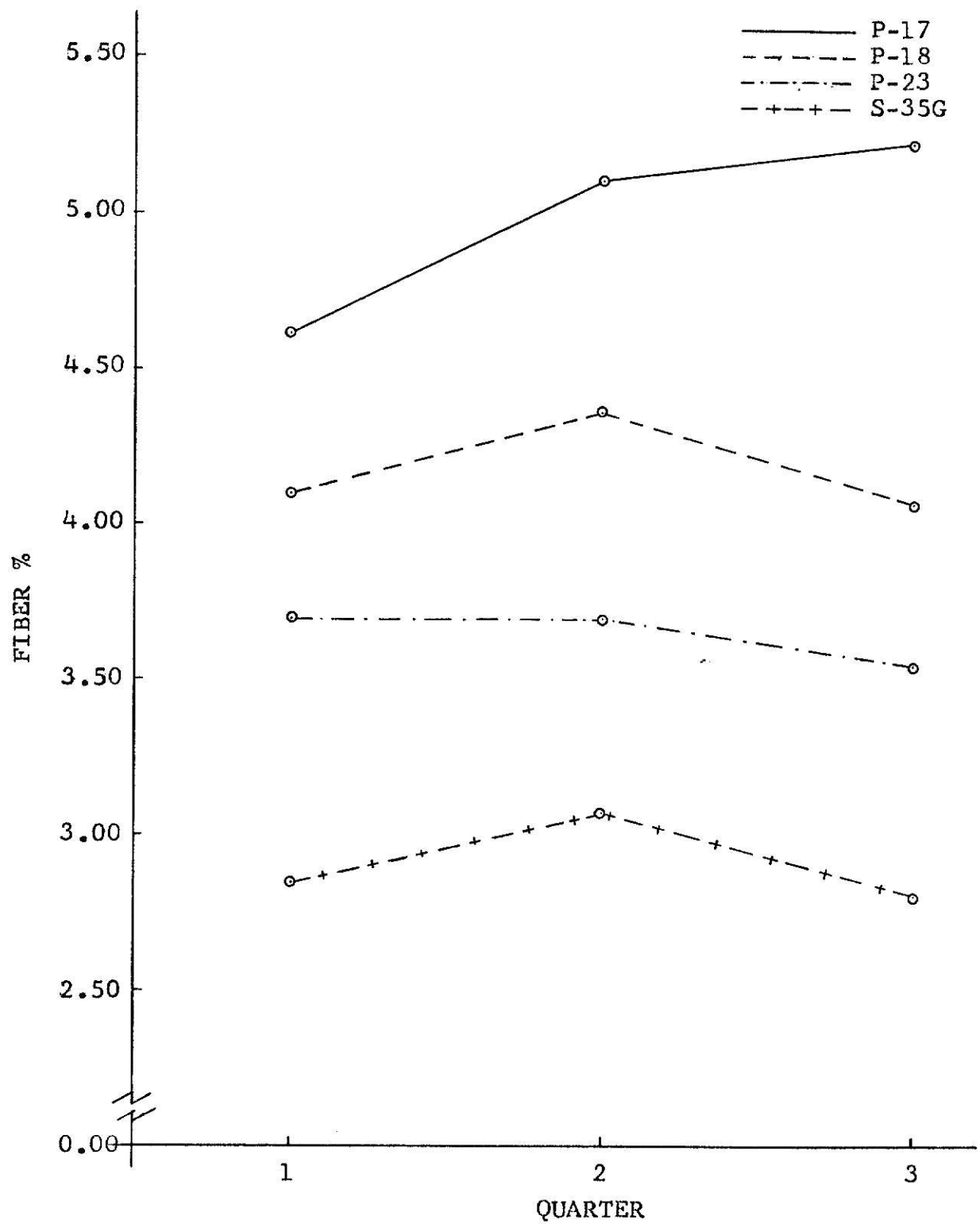


Fig. 4.1 Average Quarterly Fiber Levels of Selected Manufactured Feeds.

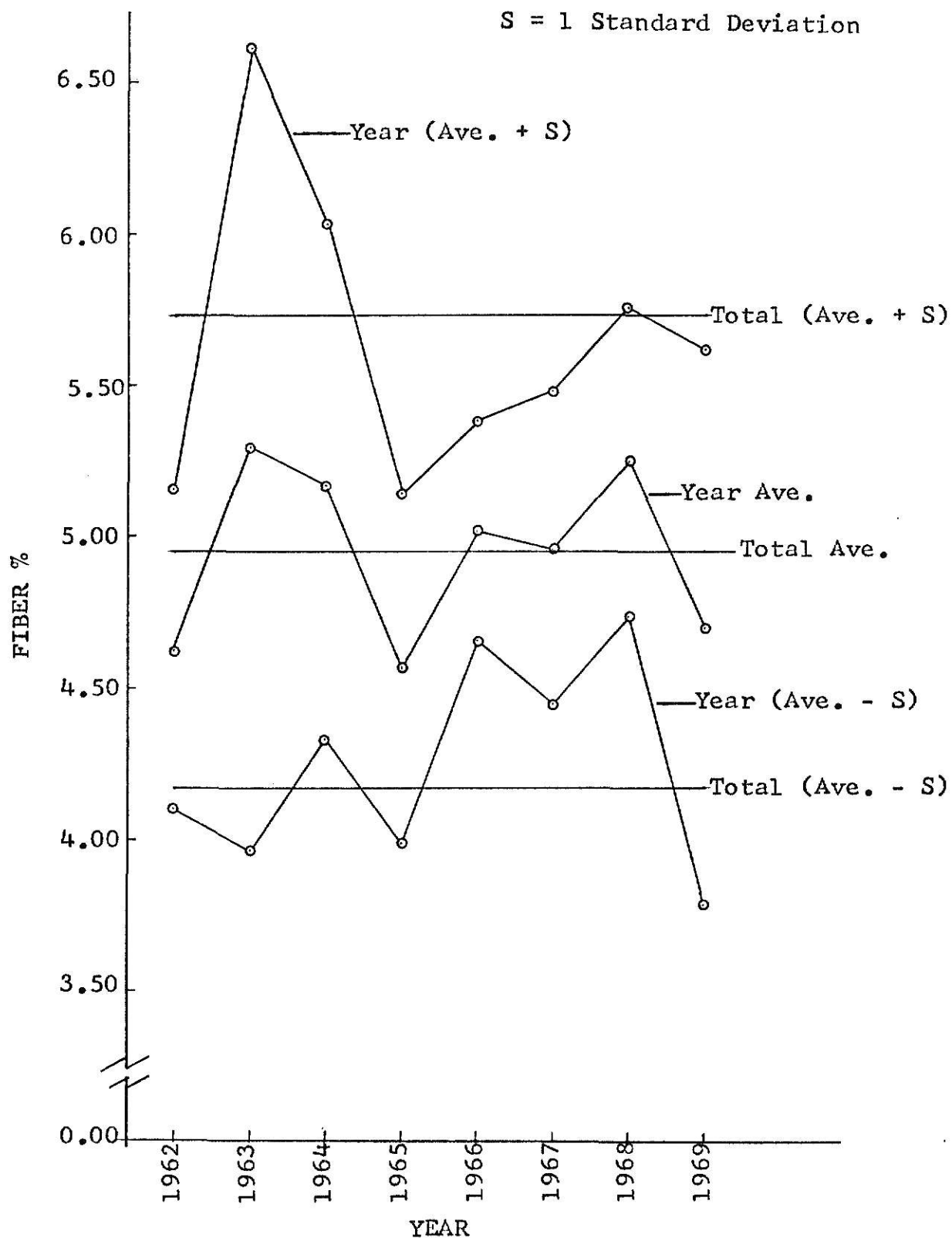


Fig. 4.2 Standard Deviations and Average Fiber Levels of P-17

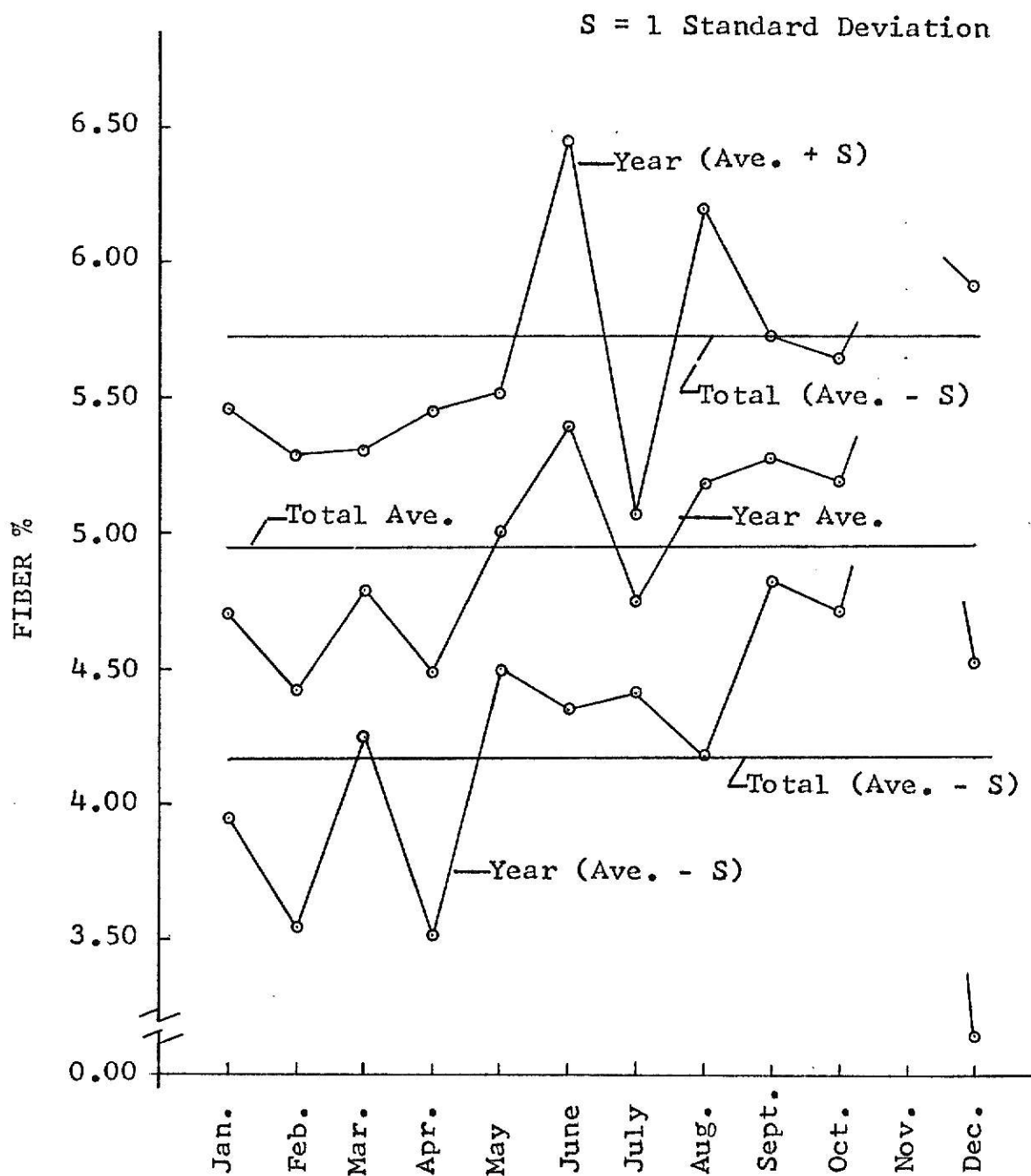


Fig. 4.3 Standard Deviations and Average Fiber Levels of P-17

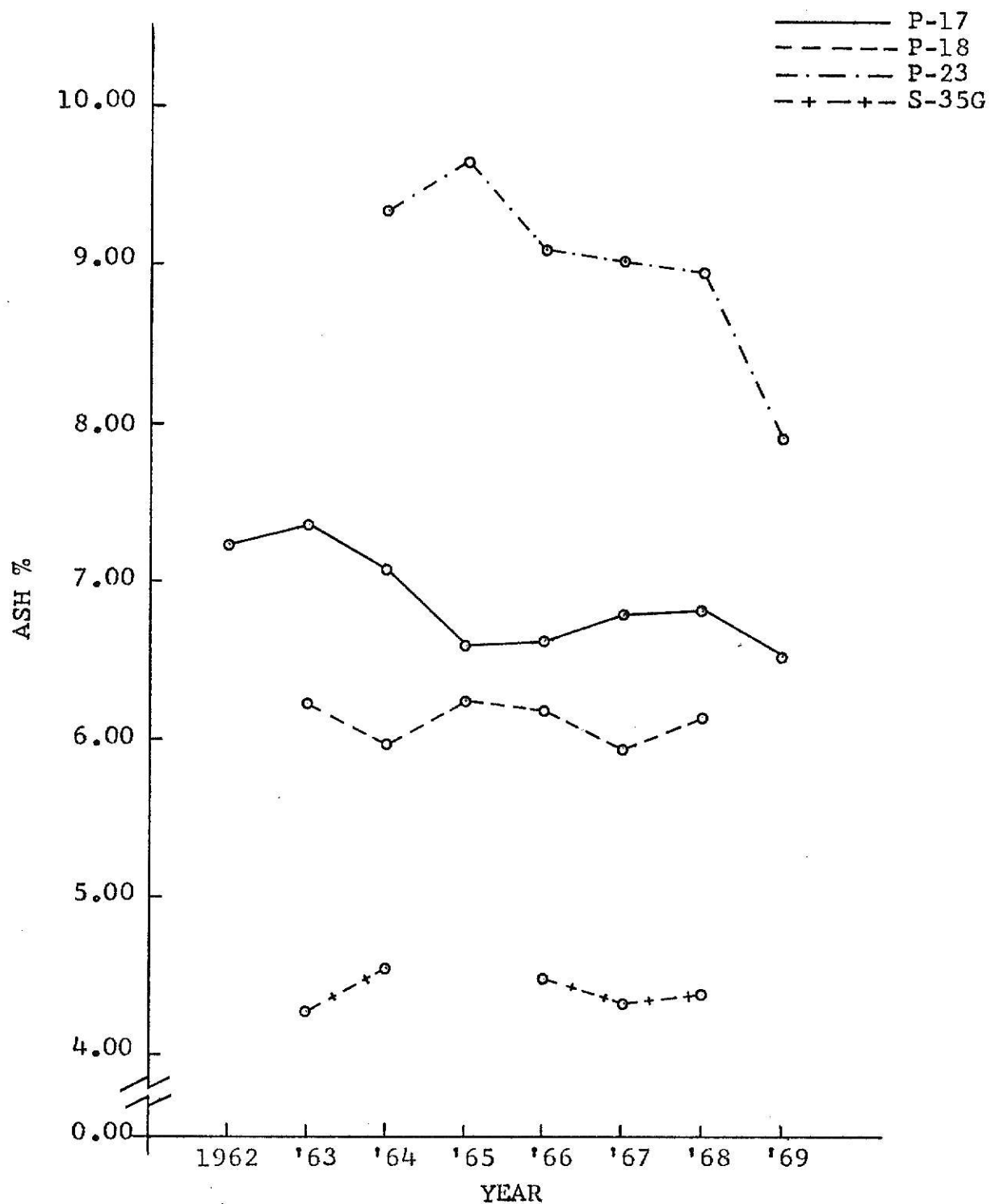


Fig. 5.0 Average Yearly Ash Levels of Selected Manufactured Feeds

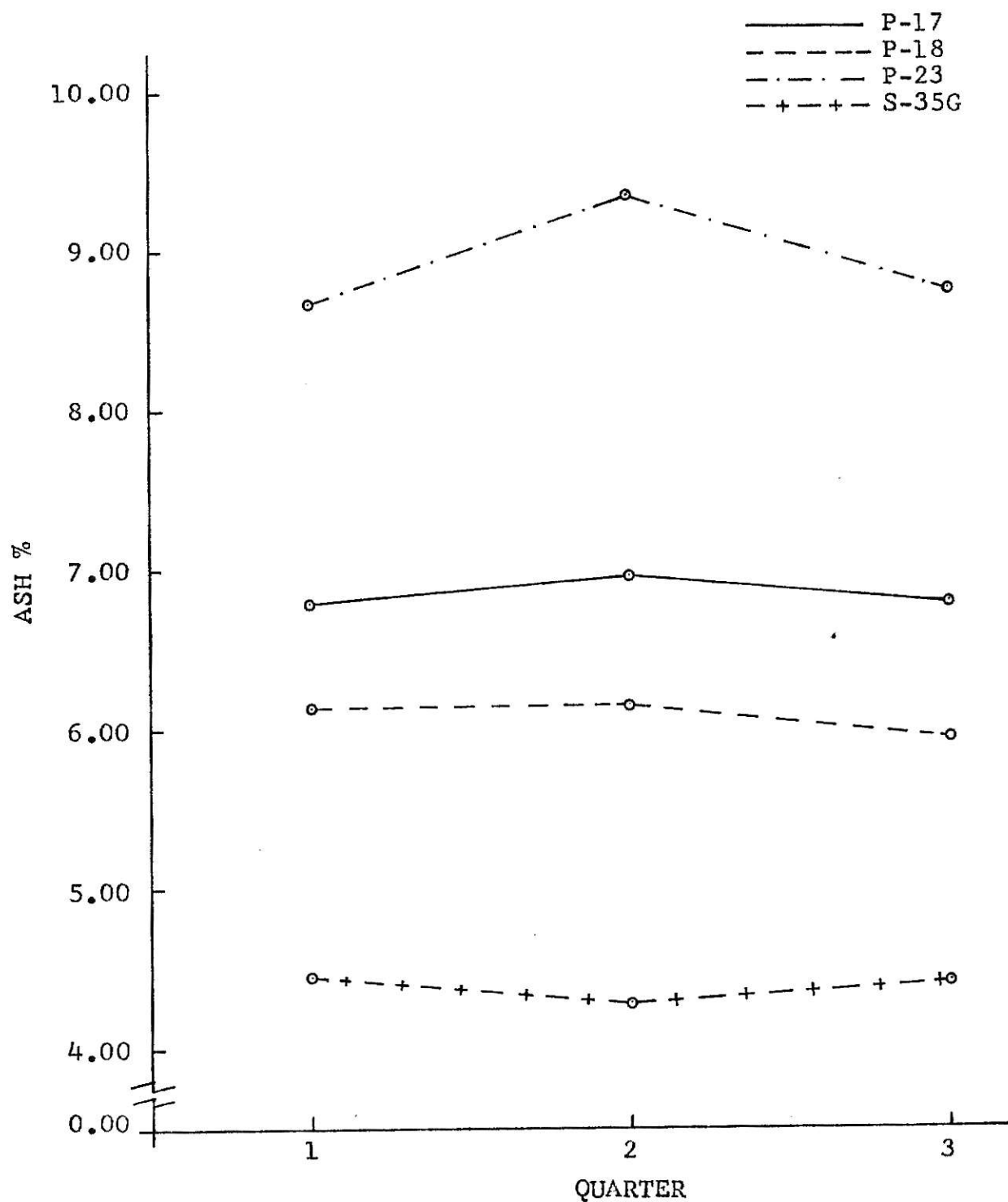


Fig. 5.1 Average Quarterly Ash Levels of Selected Manufactured Feeds

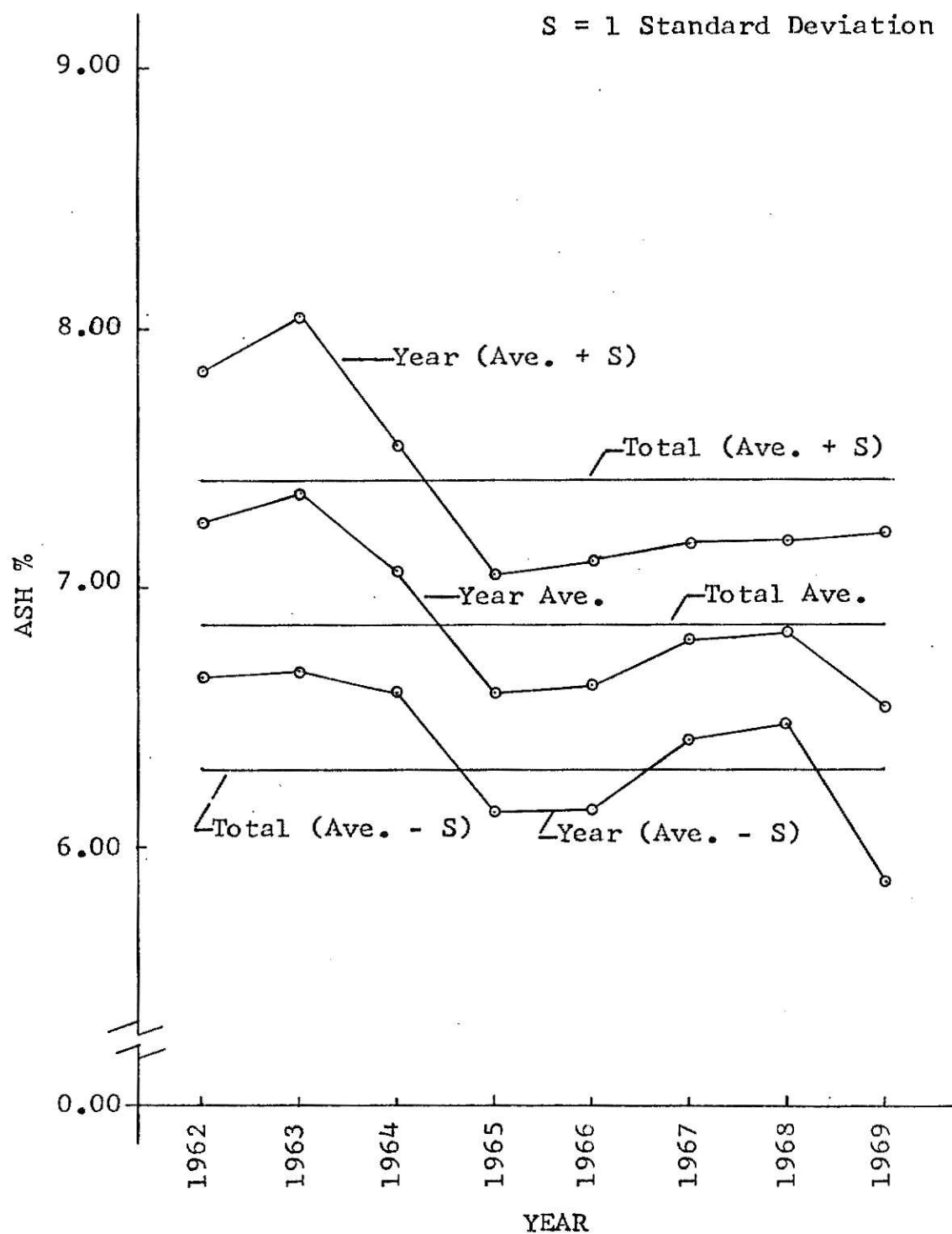


Fig. 5.2 Standard Deviations and Average Ash Levels of P-17

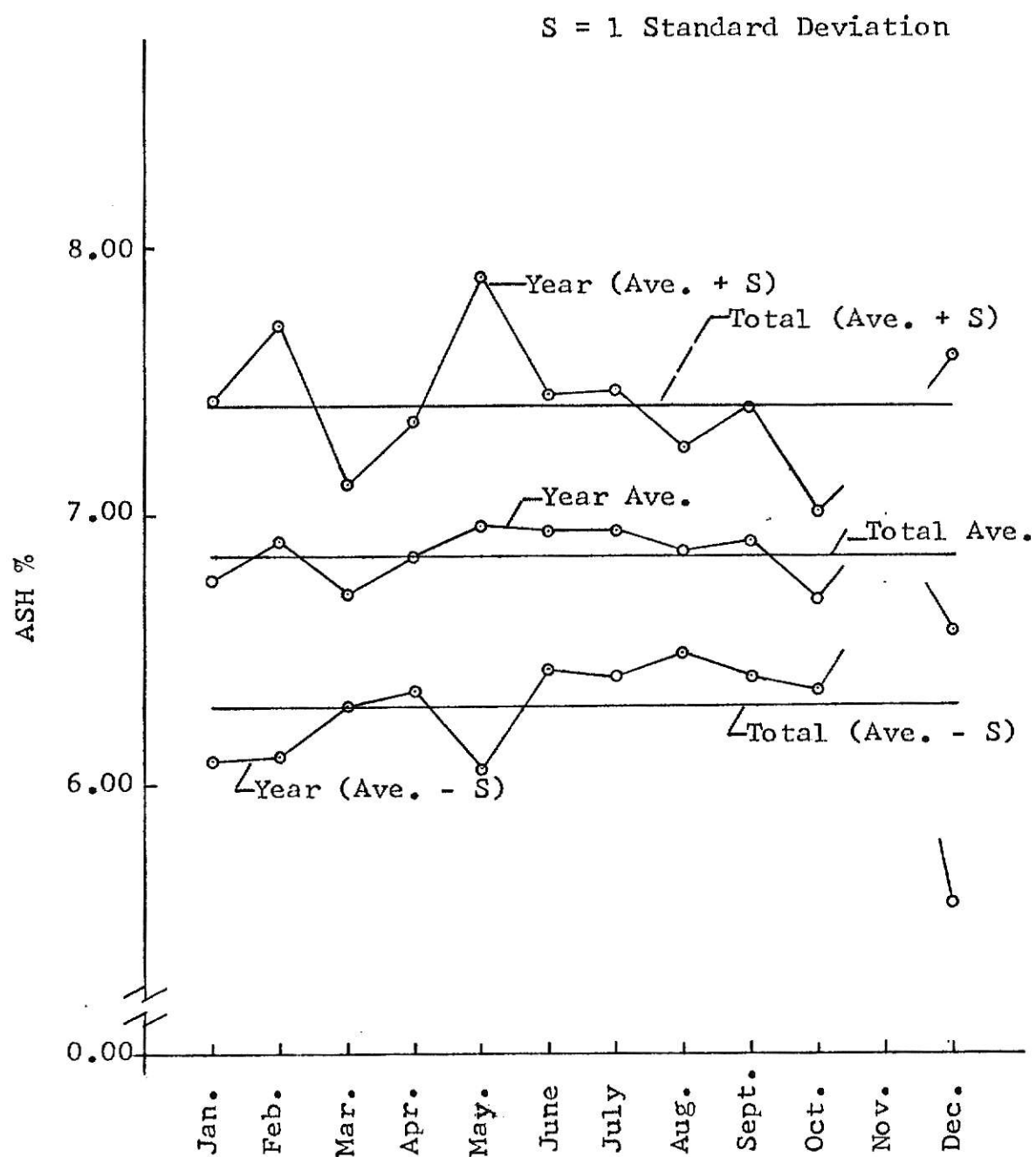


Fig. 5.3 Standard Deviations and Average Ash Levels of P-17

A STUDY OF VARIATIONS IN A GROUP OF FEED FORMULAS
FOR QUALITY CONTROL PURPOSES

by

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B. S., Universidad de San Carlos de Guatemala, 1966

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Grain Science and Industry

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1970

Variations in the proximate analysis components of four formulas manufactured in the Kansas State feed mills were studied. The formulas were: three poultry rations identified as P-17, P-18 and P-23, and one swine ration identified as S-35G. The purpose of this study was to gain knowledge about variations in finished feeds as a necessary step for future quality improvement.

The overall moisture coefficient of variation was highest (13.24%) in P-18 formula and lowest (12.38%) in P-17.

Moisture was lowest in 1964 for all formulas. This year was characterized by very low crops due to moisture shortage. An increase of feed moisture in all formulas was observed in recent years. Higher crop production and early harvesting to minimize feed losses could force the grain elevators to store larger amounts of high moisture grain with the consequent moisture increase in finished feeds.

The overall protein coefficient of variation was highest (9.87%) in P-23 formula and lowest (5.25%) in P-17. Since corn supplied a larger proportion of protein (16.4%) to P-23 than to the other formulas, this may suggest corn protein variation as the cause of such higher variation. The lower P-17 coefficient of variation was expected since the protein sources were more and therefore it was less affected by individual ingredient variation.

Total fat coefficient of variation was highest (14.5%) in P-18 followed by P-17 (13.4%) and lowest in S-35G (11.07%). High fat coefficient of variation in fish meal, distiller

solubles and meat and bone meal could be the cause of these high variations.

The overall fiber coefficient of variation was highest (15.81%) in P-17 followed by P-18 (13.71%) and lowest in S-35G (10.03%). Variations in oat, alfalfa and wheat middlings values are probably the principal factors in the high coefficient of variation.

Total ash coefficient of variation was highest (8.13%) in P-17 and lowest (4.56%) in S-35G. The high P-17 coefficient of variation was expected since a large amount (29.8%) of its ash content is supplied by meat and bone meal, which is the ingredient with greatest variation due to source and manufacturer. Ash values are also the most affected by sampling errors due to separation of the added minerals.

The lowest coefficient of variation in fat, fiber and ash in formula S-35G is probably influenced by the fact that most data for this formula was concentrated in the second half of 1967 and the first months of 1968 and therefore was less affected by year variation.