AIR CLASSIFICATION OF A COMMERCIAL HARD WHEAT FLOUR FROM MEXICO FOR COOKIE MANUFACTURE

by

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INTRODUCTION

Due to the shortage of cereals in undeveloped countries, most are trying to get better yields by improving wheat varieties. Mexico being among these developing countries, a great deal of research has been conducted on new wheat varieties and fertlizer application, most of the wheat being harvested in Mexico is of the hard wheat varieties.

It is possible to produce cookies and crackers from hard wheat varieties, but due to quality and protein content of hard wheats, the quality of the product is not the same as that produced from soft wheats. In trying to find a solution for the cookie industry in Mexico, an air-classification study was conducted and the results are shown in this report.

REVIEW OF LITERATURE

Introduction of Air-Classification to the Milling Industry: The introduction of air classification of flour to the milling industry (2) presented a method which allows the miller to more closely control the uniformity of his product. The ability to regulate the protein level of a flour fraction results from the nature of the structure of the wheat kernel and the proper application of processing methods to it.
The principles of air classification are based on the differences which exist between endosperm chunks, individual protein particles and starch granules. Through careful manipulation of centrifugal forces and air velocities, par-

ticles of different shape, size and density can be separated and concentrated into groups more uniform in chemical and physical characteristics than the original heterogeneous parent flour.

The problem of the milling industry has become one of controlling the factors which can influence the response of the wheat flour to fine grinding and air classification (13). In order to obtain the largest possible fractions which have distinct and desirable chemical and physical properties, the cereal chemist must investigate the factors which can influence reduction of particle size during processing. Fine grinding, as achieved by the use of an impact mill is the main means of obtaining a high degree of particle size reduction beyond that which occurs during the conventional milling process.

Examples of the application of air classification in the milling industry are quite numerous in the literature. They are concerned mainly with maximum utilization of a wheat flour made possible by the production of several flour fractions which are quite varied in chemical and physical properties. One example of maximum utilization of flour for several different types of bakery products is reported by Wichser (26). Through the shifting of protein by air classification a hard wheat flour of 11.7% protein content can yield (a) a fraction of 12.7% protein content which is quite desirable as bread flour, (b) a fraction of 7.0% protein content, used for cookies and crackers and (c) a fraction of 6.0% protein content, superior in many respects to a soft wheat flour when used for cake baking.

Structure of Starchy Endosperm: In order to comprehend the reason why a selective shift of protein and starch occurs when a conventionally milled or a finely ground flour is subjected to air classification one must be familiar with the particle size relationship of the various endosperm constituents.

As early as 1904, Cobb (6) demonstrated the position of starch in a proteinaceous matrix and showed that the protein content of endosperm was highest in the cells lying directly beneath the aleurone cell layer. Progressively, towards the interior of the kernel, a decrease in protein content occurred. The three basic types of starchy endosperm cells typically found in flour particles have been described and illustrated with sketches by Kent and Jones (15). The three types of cells, peripheral, prismatic and central, represent three distinct regions of the starchy endosperm portion of the wheat kernel. The peripheral cells lie directly beneath the aleurone cell layer. The cheeks of the kernel contain the central cells while the prismatic cells extend nearly to the crease from the back of the kernel.

The starchy endosperm cells contain many starch granules imbedded in a proteinaceous matrix. The central and prismatic cells contain large starch granules, 28-33 microns in diameter, with an upper limit of 50 microns (5). Small granules, two to eight microns in diameter, are packed between the large granules. Starch granules intermediate in size are found in the peripheral cells of the endosperm.

In a simplified description of the starchy endosperm, Elias (8,9) described a single endosperm cell as numerous starch granules imbedded in a protein matrix and enclosed by an extremely thin cellulose wall. The starch granules will vary from one micron to over 40 microns in diameter. The air classified fraction composed of particles smaller than 15 microns are small starch granules, broken granules and broken portions of the protein matrix. The majority of the free starch granules will be contained in the 15 to 40 micron fraction, while particles over 40 microns will be mostly endosperm chunks.

General observations by Kaiser (14) have shown that wheat starch ranges from one to 55 microns in diameter. Approximately 3% of the granules, by weight, are smaller than 17 microns and 20% are over 40 microns in diameter. Thus when 17 and 40 microns are used as the cut points, three fractions are obtained. The fraction composed of particles smaller than 17 micrones is one of the low starch and high protein, the 17 to 40 micron fraction is high in starch and low in protein and the remaining material, over 40 microns in diameter, is composed chiefly of agglomerates of starch, protein, etc. which very closely resemble the particles of the parent flour.

Not only does particle size play an important part in air classification, but also the difference in the density of wheat protein and starch serves as one of the bases on which separations are made. Hess (12) reports the density to be 1.317 ± 0.001 g/cm^3 for protein, and 1.4945 to 1.5046 ± 0.0005 g/cm^3 for starch, small granules being heavier than large ones.

Gracza (10.11) found that the specific gravity of the individual fractions obtained from air classification of a hard spring wheat flour ranged from 1.430 g/cm^3 for the high protein fraction to 1.465 g/cm^3 for the high starch fraction. The parent flour had a specific gravity of 1.447 g/cm^3. This in contrast to a soft wheat flour whose individual fractions ranged in specific gravity from 1.403 to 1.487 g/cm^3.

Air Classification Studies of Soft Wheats: Much of the work reported in the literature on the practical application of fine grinding and air classification has been applied to the wheats grown in the soft wheat area of the mid-west, where they acquire semi-hard characteristics. Because these wheats are too low in protein to yield good bread flours, studies have been conducted to investigate the possibilities of blending high protein fractions with low protein flours. The high-starch, low-protein fractions are considered to be suitable for some industrial starch purposes. Omar variety, a White Club wheat and Brevorand Gaines varieties both soft white winter wheats, have been air classified before and after fine grinding (18,20,23). Pfeifer et al. (18) found that flours from Omar and Brevor varieties could be fractionated into eight portions which ranged in protein content from 3.1

to 15.8% and 2.4 to 22.0% respectively, without regrinding. However, when the flour was reground by passing it three times through a pin mill at 14,000 RPM the range of protein was increased. Omar fractions ranged from 2.2 to 17.0% in protein content, Brevor from 1.3 to 25.1%. Of equal importance was the change in amount of each fraction as a result of fine grinding. The high-protein fraction of Omar flour increased from 20.0% before pin milling to 28.2% of the total flour after pin milling. The amount of coarse chunky material was decreased from 21.2 to 6.7% of the total flour. The corresponding shifts in percentages for Brevor were from 16.7 to 24.2% of the total flour for the high protein fraction and a decrease from 13.0 to 5.7% for the chunky material.

The similarity in response obtained from soft wheat flours is further substantiated by the work of Gracza (10). When an Ohio Soft Red Winter wheat flour was classified without further regrinding, the protein in the individual fractions ranged from 2.5% to 22.2%. Fortynine percent of the flour had a protein content of less than 4.0%. Brevor variety wheat flour yielded a fraction which contained less than 4.0% protein that amounted to 45.4% of the total flour. For Grains variety, the low protein fraction resulting from air classification without fine grinding represented 43.3% of the total flour.

Pfeifer et al. (19) was able to obtain a starch fraction, from a white club wheat flour, having a protein content of 1.7%. The process used to obtain this low protein fraction consisted of fine grinding the flour, classifying, combining and regrinding all fractions having a protein content lower than the protein level of the parent flour and reclassifying into six or seven fractions.

Pence, et al. (17) working with air classified fractions from selected Pacific Northwest wheats found that nore of the low protein fractions made good cookies. It was also found that reducing the particle size of the coarse residue fractions and starting flours by regrinding, lowered cookie baking performance. Probably granulation was a governing factor.

Air Classification Studies of Hard Wheats: The response of hard wheats to fine grinding and air classification is not the same as the response obtained when working with soft wheat flours. Stringfellow and Peplinski (24) found that Kansas Hard Red Winter Wheat could be separated into fractions ranging from 5.4 to 27.9% in protein content. If fine grinding was employed the range was from 4.3 to 31.7% protein. However, not all of the Hard Red Winter wheat varieties were similar in their response. Bison and Triumph varieties, when reground three times and classified into eight fractions, had protein shifting values of 60 and 59% respectively. This is compared to protein shifting value of 39 and 36% for Comanche and Pawnee, respectively. Because all of these Hard Red Winter wheats were milled under similar conditions, the large difference in protein shifting response would indicate the influence of certain inherent varietal characteristics on the breakdown of the starchy endosperm and protein matrix. When the Hard Red Winter (HRW) wheats were classified without prior fine grinding, the percent of protein shift was 34, 34, 20 and 20 for Bison, Triumph, Comanche and Pawnee varieties, respectively. Thus not only did variety affect the amount of size reduction during milling, but it also influenced respose to fine grinding.

High-Protein fractions air-classified from flours of five HRW wheat varieties (Bison, Comanche, Pawnee, Triumph and Wichita) were added to three base flours (9.4 to 10.6% Protein) in amounts to give blends of 12% Protein (3). Bread and dough properties of the blends were significantly influenced by both the high-protein fraction and base flour. In addition, farinograph stabilities and loaf volumes were significantly affected by interaction of high-protein fraction and base flour and by the method of obtaining the high-protein fraction. The high-protein fraction separated from a flour reground only once gave longer mixing stabilities and larger loaf volumes in blends than did either of the two fractions separated from the corresponding flour reground three times. Quality of protein in high-protein fractions was probably most responsible for differences in their characteristics, but the behavior of other components, particularly starch and ash, may affect the suitability of a sample for air classification when high-protein fractions are an important product.

Bean, et al. (3,4) working with the low protein fractions found a wide range of cookie and cake baking performance attributed mainly to varietal differences in parent flours. The Pawnee low-protein fractions were best for cookies and layer cakes, whereas the Bison and Comanche fractions were unsatisfactory even at reasonable protein levels. Triumph fractions performed similarly to Pawnee, and Wichita fractions were intermediate.

Lower molecular weight proteins of gluten (gliadin) contribute to the extensibility and non elastic characteristics of a dough (21). These proteins also account for the effect of reducing the mixing time in a flour.

MATERIALS AND METHODS

Flour produced from a blend of soft and hard wheat varieties was used in these experiments. The flour was milled in a Mexican commercial mill and it was planned to be used for making cookies.

From 76% Hungarian extraction of this commercial mill, 36% was taken as flour 1, and 40% as flour 2.

Flour produced in the same commercial mill from 100% Soft Wheat, was used as a control flour. From 76% Hungarian extraction, 36% was taken as control flour 1, and 40% as control flour 2.

The data representing protein content and extraction rate for the flours are listed in Table I.

<u>Air Classification</u>: The parent flours 1 and 2 were fractionated 5 months after milling. Both flours were fractionated as unground and reground flours. The parent flours were fractionated in a Pillsbury Laboratory-model turbo-air classifier. This fractionation produced five fractions from the parent flour. The finest fraction of highest protein content was removed first. The remaining coarse material was passed through the classifier again. This procedure was repeated until five fractions were obtained. Fractionation by air-classification made simultaneous use of size, shape and density of the particles.

Each of the flours were passed through the classifier in the same way. The classifier settings for the four stage

TABLE I

FLOUR	FLOUR PROTEIN PERCENT *	FLOUR EXTRACTION PERCENT
Flour 1 Unground	9.9	36%
Flour 2 Unground	9.6	40%
Control Flour 1	11.4	36%
Control Flour 2	11.3	40%

* Reported on 14 percent M.B.

fractioning which produced five fractions were as shown in Table 2.

The fractionation cut-point was made by adjustment of classifier speed, angle of Louvre curtain, direction of classifier blade curvature, effective depth of classifier chamber 9decks), and feed rate. Each stage or "cut" produced a fine fraction which was collected, and a coarse fraction which was further classified into two-fractions by readjusting the classifier for a coarser cut. This procedure was repeated until four fine fractions and one coarse fraction were obtained. The five fractions thus obtained from the parent flour (a) were separated and designated as below:

B) Primary high protein, the first fine fraction.

C) Secondary high protein, the second fine fraction.

D) Small starch, the third fine fraction.

E) Large starch, the fourth fine fraction.

EE) Chunks, the remaining coarse fraction.

Figure 1 shows a cross section of the type of separator used. Flour was fed into the top of the machine onto a rotating plate which deagglomerated and imparted centrifugal force to each particle. The particles were thrown outward through a stream of air which retained the fine particles by a drag force (Centripetal force), but which could not overcome the centrifugal force of the larger particles. The flour was thereby separated into fine and coarse fractions.

Fine Grinding: Flours 1 and 2 were reground by passing them once through an Alpine pin mill, operated at 11,200 RPM for

TABLE II

	RPM	DECK	CURVATURE OF CLASSIFIED BLADES	LOUVRE CURTAIN	FEED RATE
1st stage	5800	6	Forward	10^{o}	100 lbs/hr
2nd stage	5800	6	Backward	10^{o}	100 lbs/hr
3rd stage	3600	2	Backward	10^{o}	50 lbs/hr
4th stage	3600	2	Backward	35^{o}	25 lbs/hr

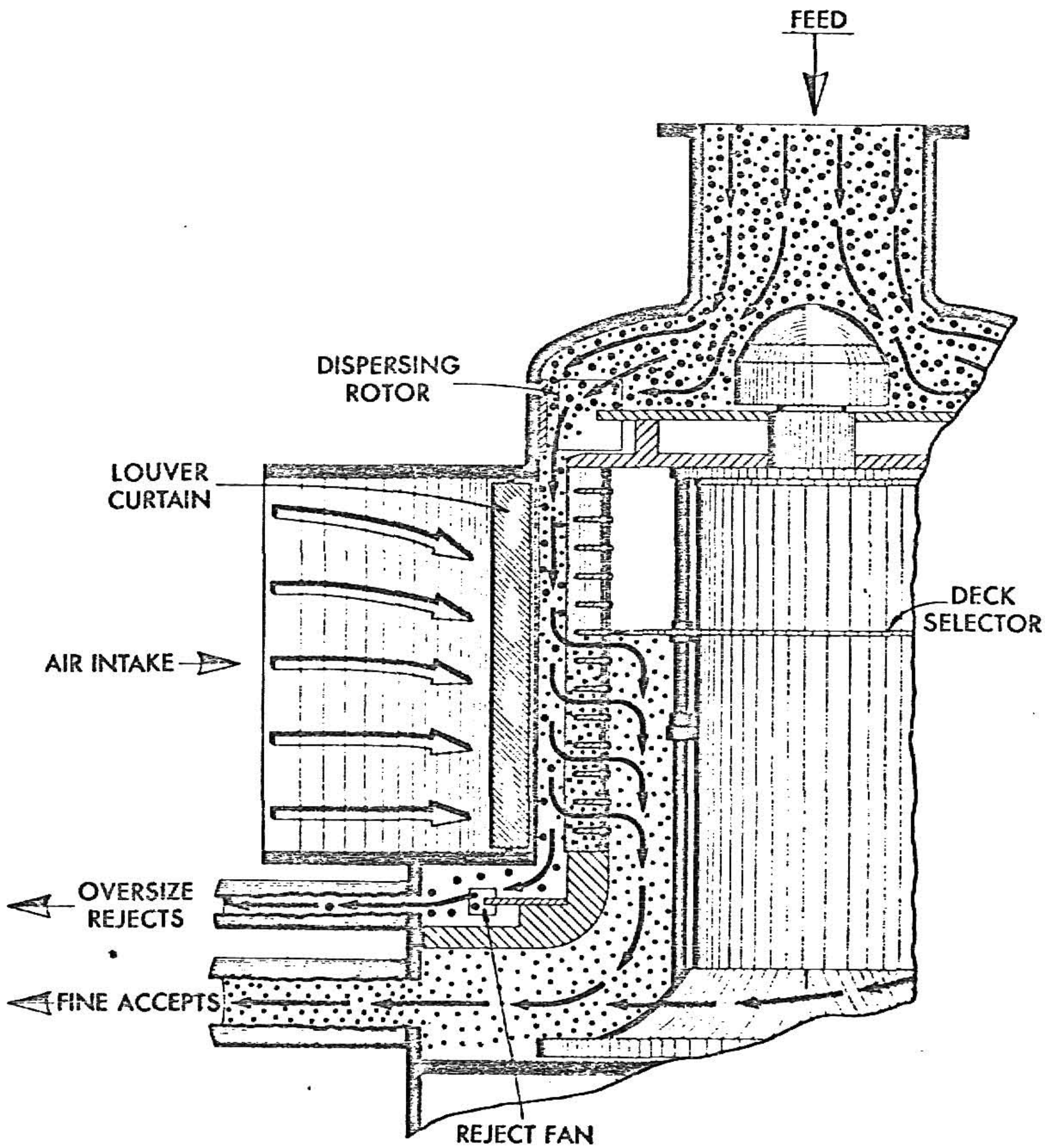


Figure 1 A Schematic Diagram of how Air Classification can be used to separate coarse and fine particles

Flour 1 and 9,200 RPM for Flour 2. A feed rate of approximately 15 pounds per hour was employed.

Blending: It was intended at the beginning to blend D and E fractions for cookie making, and B, C and EE fractions for bread making purposes In trying to raise the percentage of the flour useful for cookies, a combination of D, E and EE was made to get different levels of protein and particle size. EE fraction was combined in an unground form and in a reground form to determine the effect of particle size in cookie quality. Combinations of fractions C, D and E were also made to compare the effect of protein content in cookie making. Combinations which were intended to have low Fisher particle size to fit in the general specification for cookie flour, were called LF (low Fisher), they were blended by using EER, except for combination specified as D, E, EE, LF which was blended by using EEU.

Analytical Determinations: The parent flour and each fraction from air classification were analyzed for protein, moisture, ash and viscosity as outlined by AACC Cereal Laboratory Methods (1).

Flour color was determined as outlined by Kent Jones & Martin color grader (16).

The cookie baking test was carried out according to the modified method as outlined by AACC Cereal Laboratory Methods (1). A normal "C & H" pure cane granulated commercial sugar and "Crisco" a vegetable commercial shortening was used instead of the one that is specified in this method. Cookies were scored according to top grain in a scale from 0 to 10.

A straight dough procedure was used for the bread baking test as shown in Table 3.

Bread was scored from one to 10 for break and shred, symmetry, texture and color.

Particle Size Analysis: The Whitby MSA method (25) was used for determining the particle size distribution of each sample. This sedimentation size analysis method utilizes the relationship between settling velocity of the particle and its size as derived from Stoke's law. Gravity settling is used for separating the coarse particles, i.e. greater than 20 microns in diameter, while centrifugal forces are employed to increase the speed of separation of the fine particles. The size of particles determined by this method is reported as Stoke's Equivalent Spherical Diameter in microns.

Average Particle Size: The Fisher Sub-Sieve Size Analyzer was used for the determination of the average particle size of a sample. This method has been fully discussed and compared with other methods of particle size determination by Croteau (7).

Statistical Analysis: Statistical analysis of the data were performed according to the linear correlation coefficient method as outlined by Snedecor (22).

TABLE III

EXPERIMENTAL STRAIGHT DOUGH PROCEDURE

INGREDIENTS	FORMULA BAKERS %	GRAMS
Flour	100	700
Water	variable	variable
Yeast	2.50	17.5
Salt	2.00	14.0
Sugar	8.00	56
Shortening	3.00	21.0
Non-fat Dry Milk (NFDM)	3.00	21.0
Arkady (Mineral Yeast Food) (MYF)	0.5	3.5

RESULTS AND DISCUSSION

The flour protein was concentrated in the fine fractions of Stages 1 and 2, and the starch in the fine fractions of Stages 3 and 4. Significant increases or decreases in protein content were accompanied by similar changes in ash content.

Protein content range of the 5 air-classified fractions for 4 flour samples were as shown in Table 4.

Analytical Characteristics of the Fine Air-Classified Fractions: The analytical results for fractions of flour 1 U (Unground) are shown in Figure 2 and Table 5, and those for flour 1 R (Reground) are shown in Figure 3 and Table 6. The analytical results for fractions of flour 2 U are shown in Figure 4 and Table 7, and those for flour 2 R are shown in Figure 5 and Table 8.

The histograms of the protein of the different fractions are shown in Figure 6, ash values in Figure 7, viscocity and particle size in Figures 8 and 9 respectively. Farinograph peaktime and extensibility (cm) are shown in Figure 10 and 11 respectively. The analytical data for Whitby sedimentation are shown in Tables 18, 19, 20 and 21 of appendix I. The particle size distribution curves for the control of parent flours were plotted in Figures 12 and 13 respectively. The particle size distribution curves for the fractions were plotted in Figures 14, 15, 16 and 17 for each sample, respectively.

The histograms in Figure 6 show that the protein for all the flour samples was concentrated in the B and C fractions.

TABLE IV

RANGE OF PROTEIN CONTENT FOR 5 AIR-CLASSIFIED FRACTIONS FOR 4 FLOUR SAMPLES

	RANGE OF PROTEIN* %
Flour 1 Unground	6.0 - 21.7
Flour 1 Reground	5.6 - 22.9
Flour 2 Unground	8.0 - 19.6
Flour 2 Reground	7.7 - 23.6

* %14 M.B.

Figure 2
Lab Size Classifier
Flour 1 Unground
5 S.S.S.

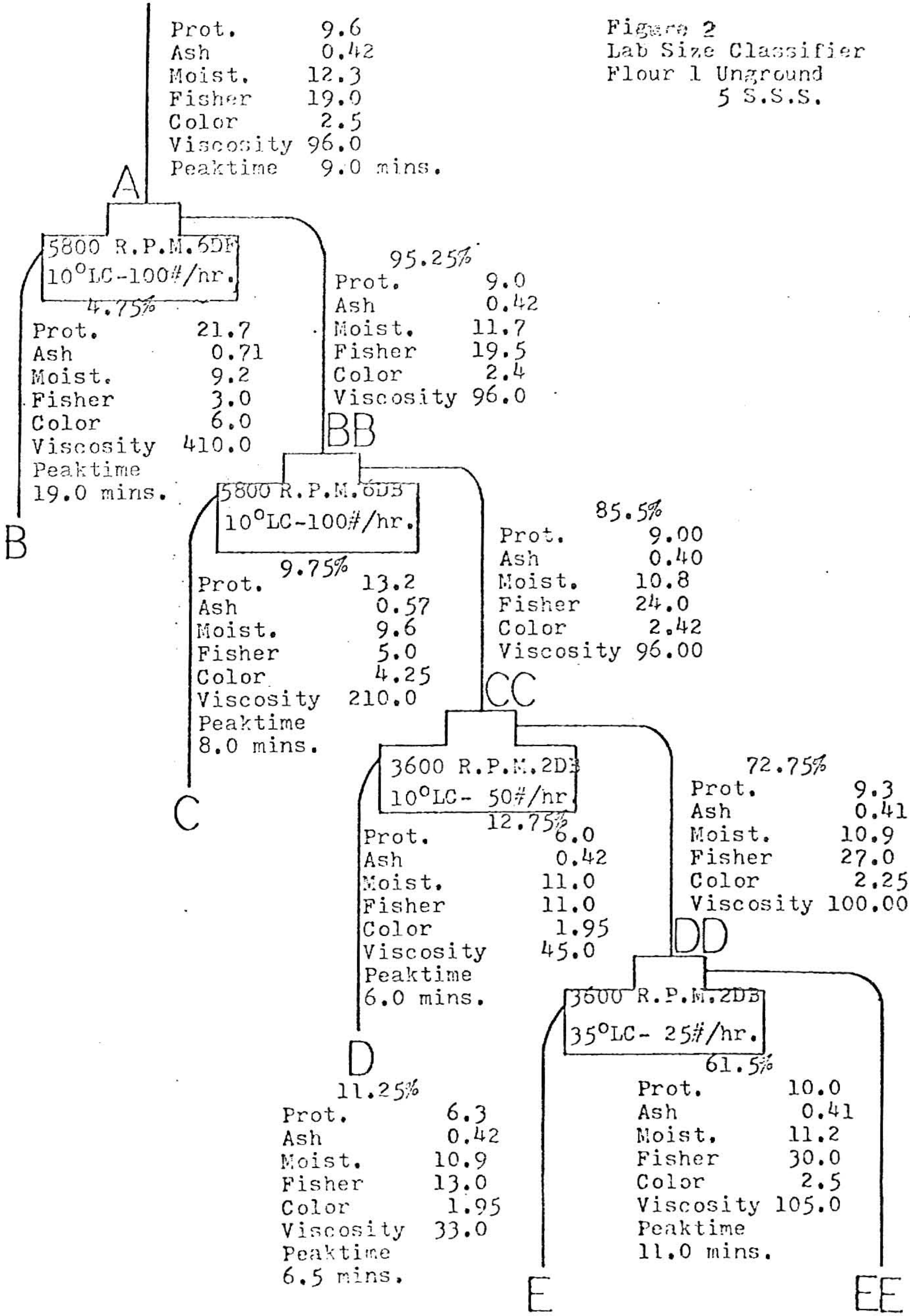


Table V Quality Characteristics of Control Flour I, Flour IU, and Fractions of Flour IU.

Characteristics	Control Flour I	Flour IU	Fractions					
			B	C	D	E	EEU	EER
Moisture %	I2.20	I2.30	9.20	9.60	II.00	I0.90	II.20	II.80
Ash* %	0.38	0.42	0.7I	0.57	0.42	0.42	0.4I	0.4I
Protein* %	9.90	9.60	2I.70	I3.20	6.00	6.30	I0.00	I0.00
Acid Viscosity* MacM	54.00	96.00	4I0.00	2I0.00	45.00	33.00	Io5.00	II0.00
Fisher S.S.S. Microns	I4.00	I9.00	3.00	5.00	II.00	I3.00	30.00	I2.00
Kent Jones Color	2.I5	2.50	6.00	4.25	I.95	I.95	2.50	2.60
Valorimeter B.U.	38.00	58.00	93.00	67.00	59.00	6I.00	8I.00	77.00
M T I	I20.00	50.00	50.00	55.00	80.00	80.00	30.00	30.00
Peaktime Mins.	2.50	9.00	I9.00	8.00	6.00	6.00	II.00	I0.50
Absorption %	60.00	6I.80	97.00	83.50	63.20	60.00	60.70	65.20
Resistence to Extesion B.U.	I50.00	570.00	570.00	595.00	280.00	300.00	800.00	690.00
Extensibility Cm.	200.00	I39.00	I47.00	I35.00	65.00	67.00	II6.00	I32.00
R/E	0.75	4.I	3.88	4.40	4.30	4.48	6.90	5.22

*Reported on I4.00 % M.B.

Figure 3
Lab Size Classifier
Flour 1 Reground
5 S.S.S.

A

Prot.	9.6
Ash	0.42
Moist.	12.3
Fisher	11.50
Color	3.00
Viscosity	110.00
Peaktime	6.5 mins.

5800 R.P.M. 6DF
10 L.C.-100#/hr

B — 5.25%

Prot.	22.90
Ash	0.72
Moist.	10.00
Fisher	2.90
Color	5.70
Viscosity	415.0
Peaktime	18 mins

BB — 94.75%

Prot.	9.0
Ash	0.41
Moist.	11.50
Fisher	13.60
Color	2.20
Viscosity	105.0

5800 R.P.M. 6DB
1 OLC-100#/hr.

C — 13.50%

Prot.	12.30
Ash	0.59
Moist.	10.60
Fisher	5.20
Color	5.10
Viscosity	200.00
Peaktime	7.5 mins.

CC — 81.25%

Prot.	8.20
Ash	0.39
Moist.	11.30
Fisher	17.50
Color	2.10
Viscosity	110.0

3600 R.P.M. 2DB
10 LC-50 #/hr.

D — 17.25%

Prot.	5.60
Ash	0.42
Moist.	11.20
Fisher	10.10
Color	1.30
Viscosity	45.0
Peaktime	5.5 mins.

DD — 64.00%

Prot.	8.70
Ash	0.39
Moist.	11.40
Fisher	22.00
Color	2.20
Viscosity	115.00

3600 R.P.M. 2DB
35 LC- 25 #/hr.

E — 13.50%

Prot.	5.70
Ash	0.39
Moist.	11.40
Fisher	13.20
Color	1.95
Viscosity	30.00
Peaktime	6.50

EE — 50.50%

Prot.	9.50
Ash	0.39
Moist.	12.10
Fisher	27.00
Color	2.40
Viscosity	110.00
Peaktime	10 mins.

Table VI Quality Characteristics of Control Flour I, Flour IR, and Fractions of Flour IR.

Characteristics	Control Flour I	Flour IR	Fractions					
			B	C	D	E	EEU	EER
Moisture %	I2.20	I2.40	I0.00	I0.60	II.20	II.40	I2.I0	I2.20
Ash* %	0.38	0.42	0.72	0.59	0.42	0.39	0.39	0.39
Protein* %	9.90	9.60	22.90	I2.30	5.60	5.70	9.50	9.50
Acid Viscosity * MacM	54.00	II0.00	4I5.00	200.00	45.00	30.00	II0.00	II8.00
Fisher S.S.S. Microns	I4.00	II.50	2.90	5.20	I0.I0	I3.20	27.00	I6.50
Kent Jones Color	2.I5	2.60	5.70	5.I0	I.30	I.30	2.40	2.50
Valorimeter B.U.	38.00	62.00	93.00	65.00	56.00	64.00	77.00	77.00
M T I	I20.00	50.00	30.00	60.00	80.00	80.00	30.00	35.00
Peaktime Mins.	2.50	6.50	I8.00	7.50	5.50	6.50	I0.00	I0.00
Absorption %	60.00	65.20	97.20	8I.00	62.40	58.00	60.40	65.00
Resistence to Extension B.U.	I50.00	630.00	520.00	550.00	320.00	300.00	585.00	865.00
Extensibility cm.	200.00	I36.00	I20.00	87.00	77.00	68.00	I50.00	I04.00
R/E	0.75	4.63	4.33	6.32	4.I6	4.4I	3.90	8.3I

*Reported on I4.00 % M.B.

Figure 4
Lab Size Classifier
Flour 2 Unground
5 S.S.S.

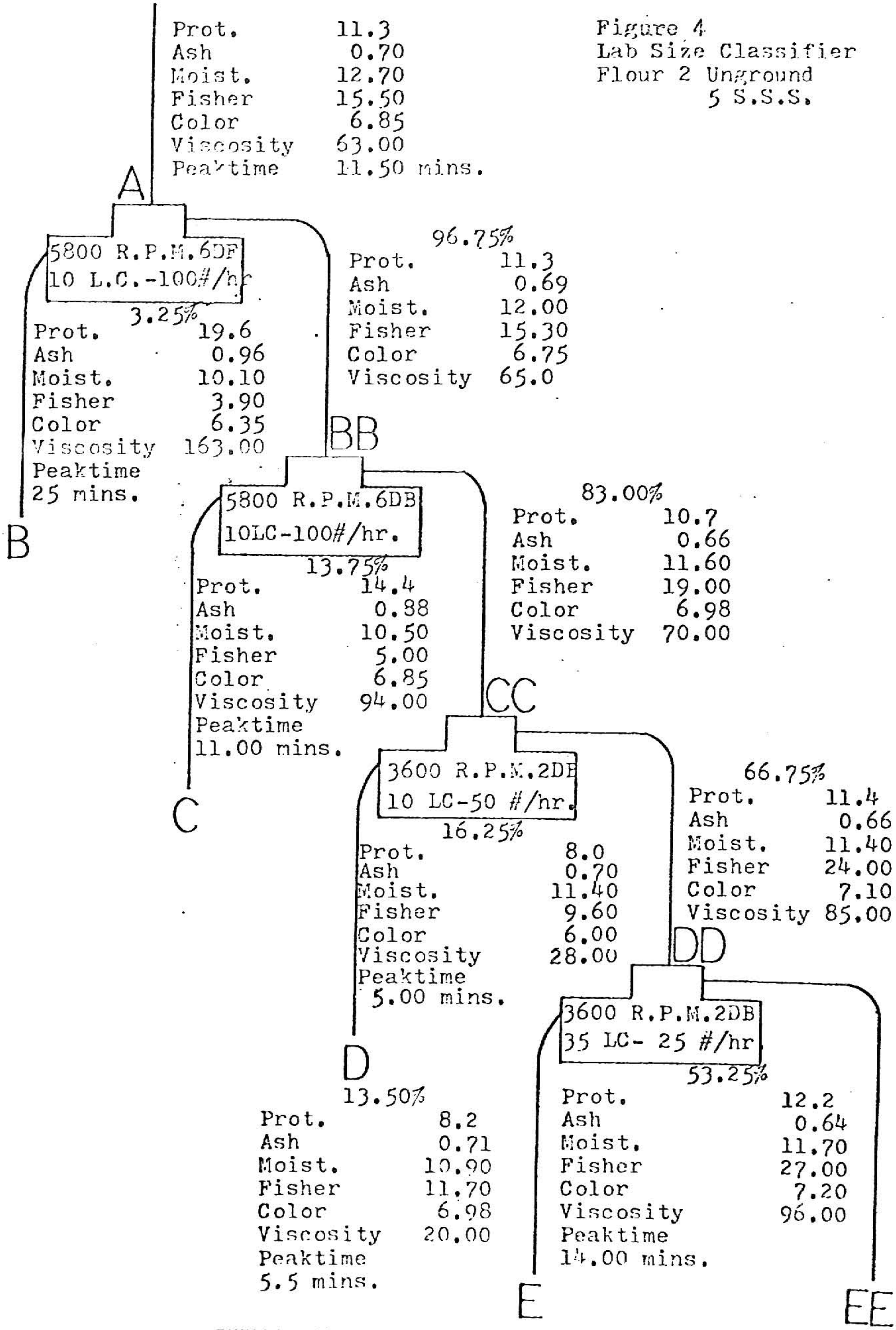


Table VII Quality Characteristics of Control Flour 2, Flour 2U, and Fractions of Flour 2U

Characteristics	Control Flour 2	Flour 2U	Fractions					
			B	C	D	E	EEU	EER
Moisture %	I2.20	I2.70	I0.I0	I0.50	II.40	I0.90	II.70	II.90
Ash * %	0.63	0.70	0.96	0.88	0.70	0.7I	0.64	0.64
Protein * %	II.40	II.30	I9.60	I4.00	8.00	8.20	I2.20	I2.20
Acid Viscosity * MacM	4I.00	63.00	I63.00	94.00	28.00	20.00	96.00	II0.00
Fisher S.S.S. Microns	I2.60	I5.50	3.90	5.00	9.60	II.70	27.00	I2.50
Kent Jones Color	5.35	6.85	6.35	6.85	6.00	6.98	7.20	7.20
Valorimeter B.U.	42.00	83.00	98.50	75.50	55.00	58.00	87.00	83.00
M T I	90.00	40.00	20.00	30.00	60.00	60.00	50.00	30.00
Peaktime Mins.	3.50	II.50	25.00	II.00	5.00	5.50	I4.00	II.00
Resistence to Extension B.U.	I50.00	560.00	578.00	700.00	360.00	460.00	680.00	760.00
Extensibility cm.	200.00	I60.00	II5.00	I20.00	75.00	83.00	I55.00	I35.00
R/E	0.75	3.50	5.02	5.83	4.80	5.54	4.39	5.62
Absorption %	60.80	63.20	96.00	78.80	64.00	63.00	63.20	68.40

*Reported on I4.00 % M.B.

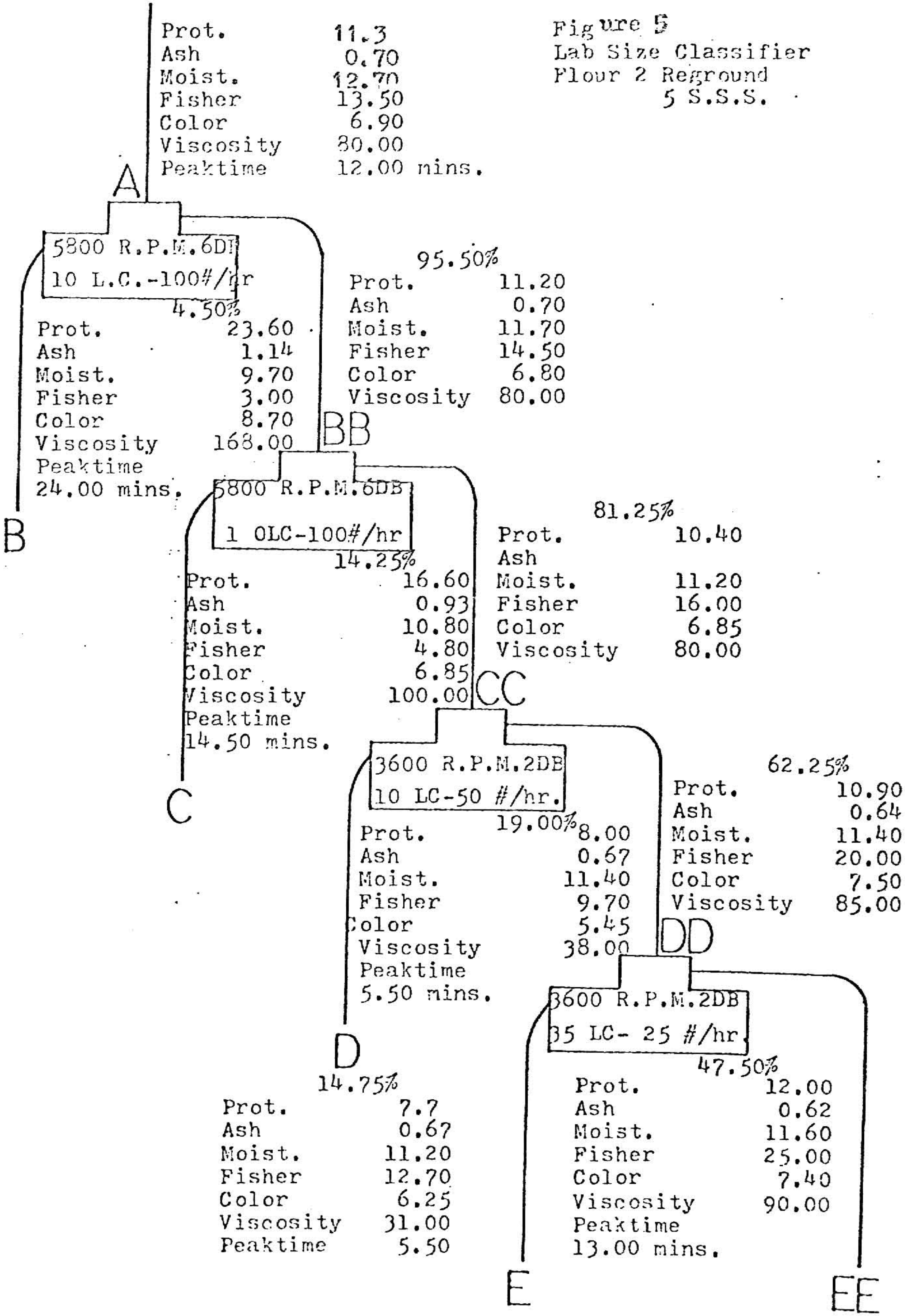


Figure 5
Lab Size Classifier
Flour 2 Reground
5 S.S.S.

Table VIII Quality Characteristics of Control Flour 2, Flour 2R, and Fractions of Flour 2R.

Characteristics	Control Flour 2	Flour 2R	Fractions					
			B	C	D	E	EEU	EER
Moisture %	I2.20	I2.70	9.70	I0.80	II.40	II.20	II.60	II.60
Ash * %	0.63	0.70	I.I4	0.93	0.67	0.67	0.62	0.62
Protein * %	II.40	II.30	23.60	I6.60	8.00	7.70	I2.00	I2.00
Acid Viscosity MacM *	4I.00	80.00	I68.00	I00.00	38.00	3I.00	90.00	I05.00
Fisher S.S.S. Microns	I4.00	I3.50	3.00	4.80	9.70	I2.70	25.00	I3.20
Kent Jones Color	5.35	6.85	8.70	6.85	5.45	6.25	7.40	7.40
Valorimeter B.U.	42.00	79.50	98.20	85.50	56.50	58.00	85.00	83.50
M T I	90.00	35.00	I0.00	70.00	60.00	60.00	30.00	35.00
Peaktime Mins.	3.50	I2.00	24.00	I4.50	5.50	5.50	I3.00	I3.00
Absorption %	60.80	64.80	98.00	80.40	62.80	62.00	62.80	68.20
Resistence to Extension B.U.	I50.00	565.00	620.00	830.00	480.00	440.00	960.00	680.00
Extensibility cm.	200.00	I60.00	I35.00	II2.00	97.00	82.00	I04.00	I38.00
R/E	0.75	3.53	4.60	7.40	4.94	5.37	9.23	4.92

* Reported on I4.00 % M.B.

Figure 6

Air-Classified Flour Fractions

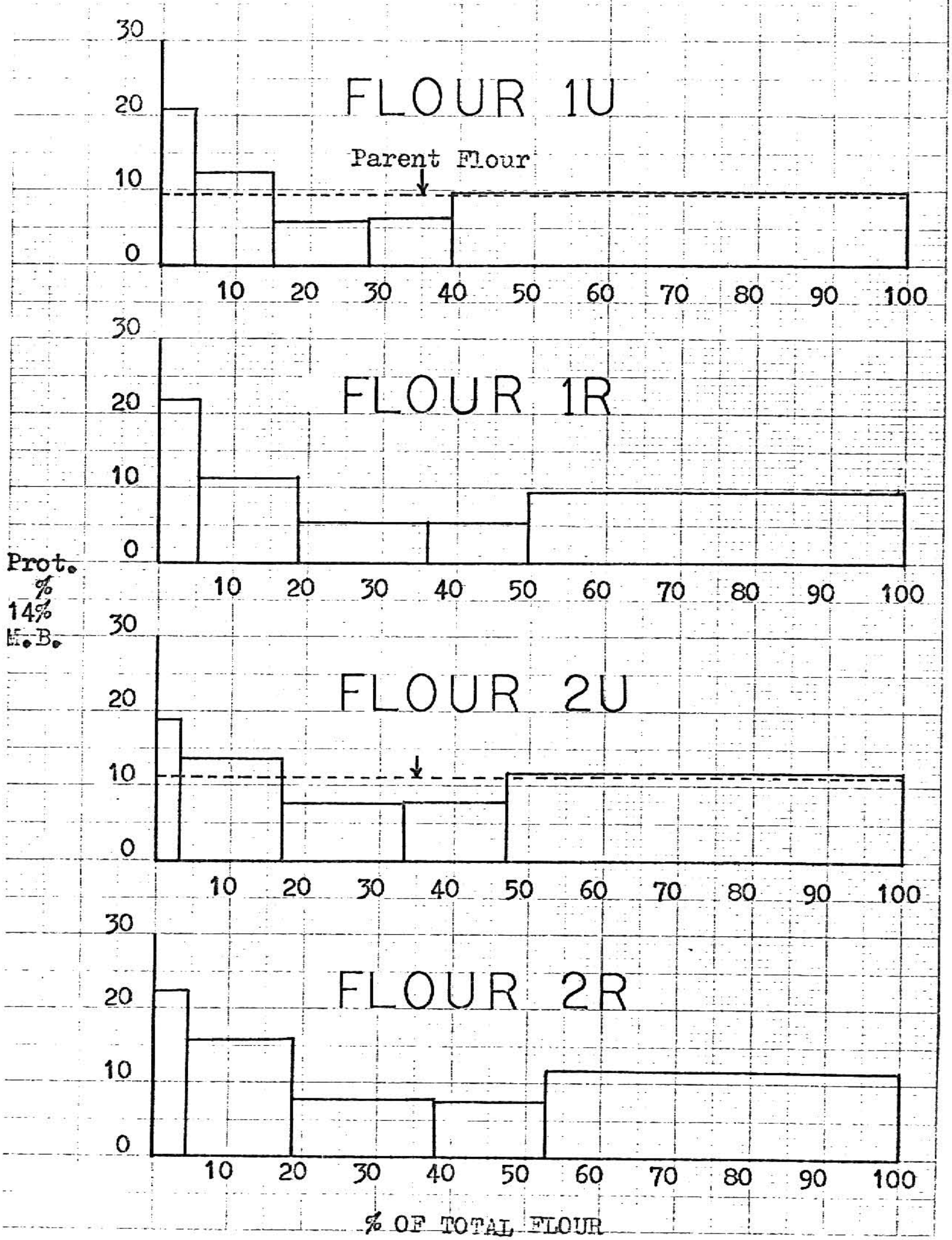


Figure 7 Air-Classified Flour Fractions

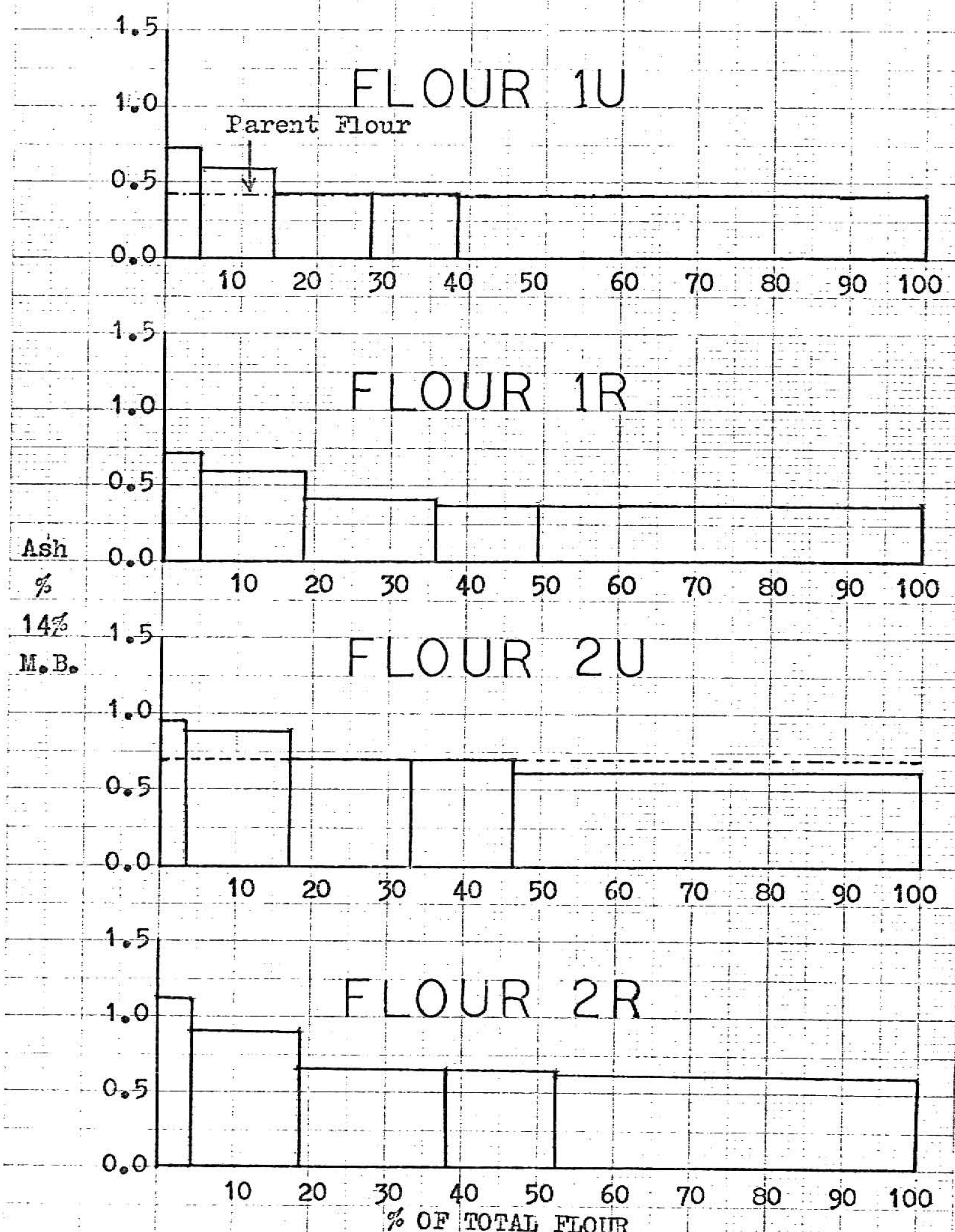


Figure 8 Air-Classified Flour Fractions

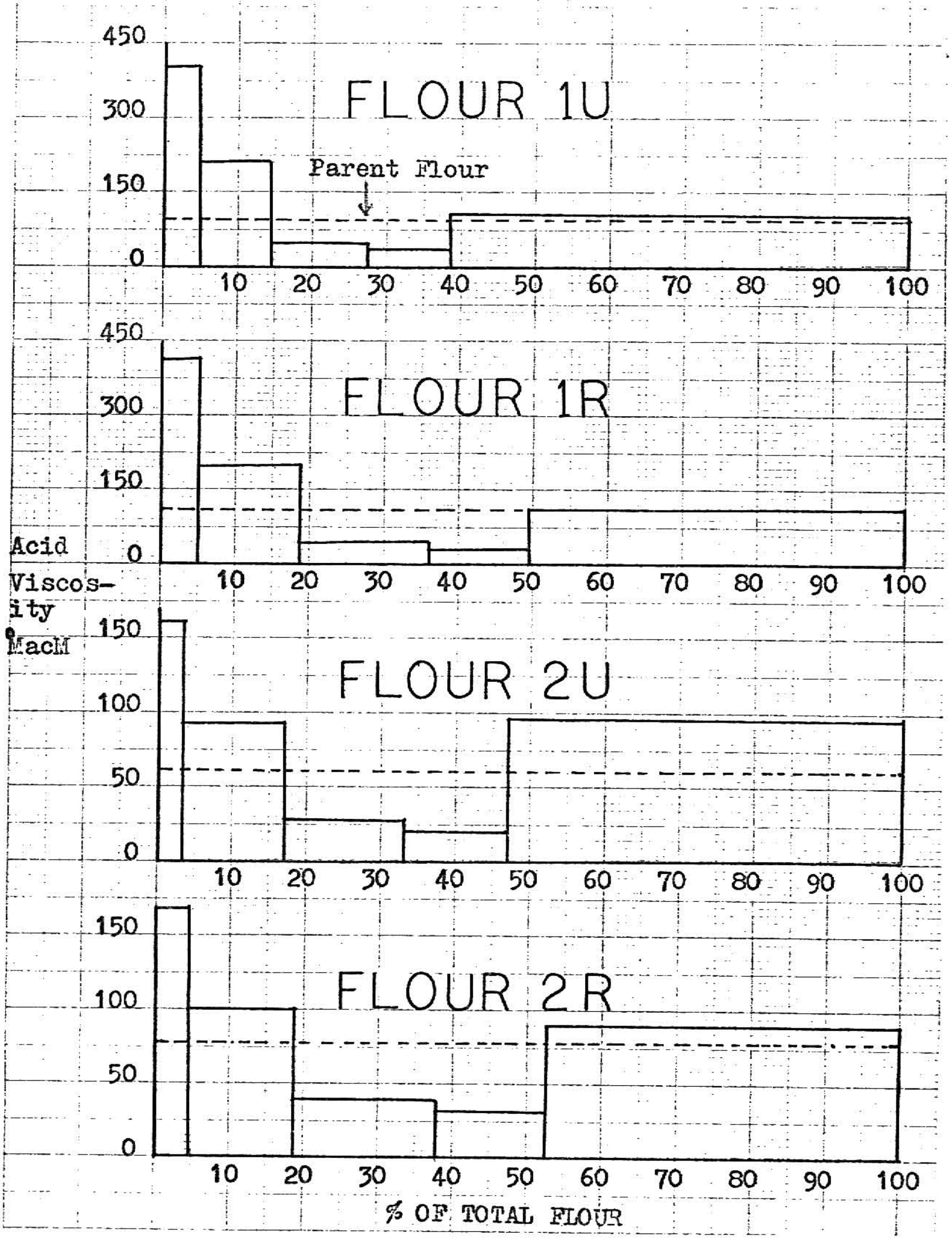


Figure 9 Air-Classified Flour Fractions

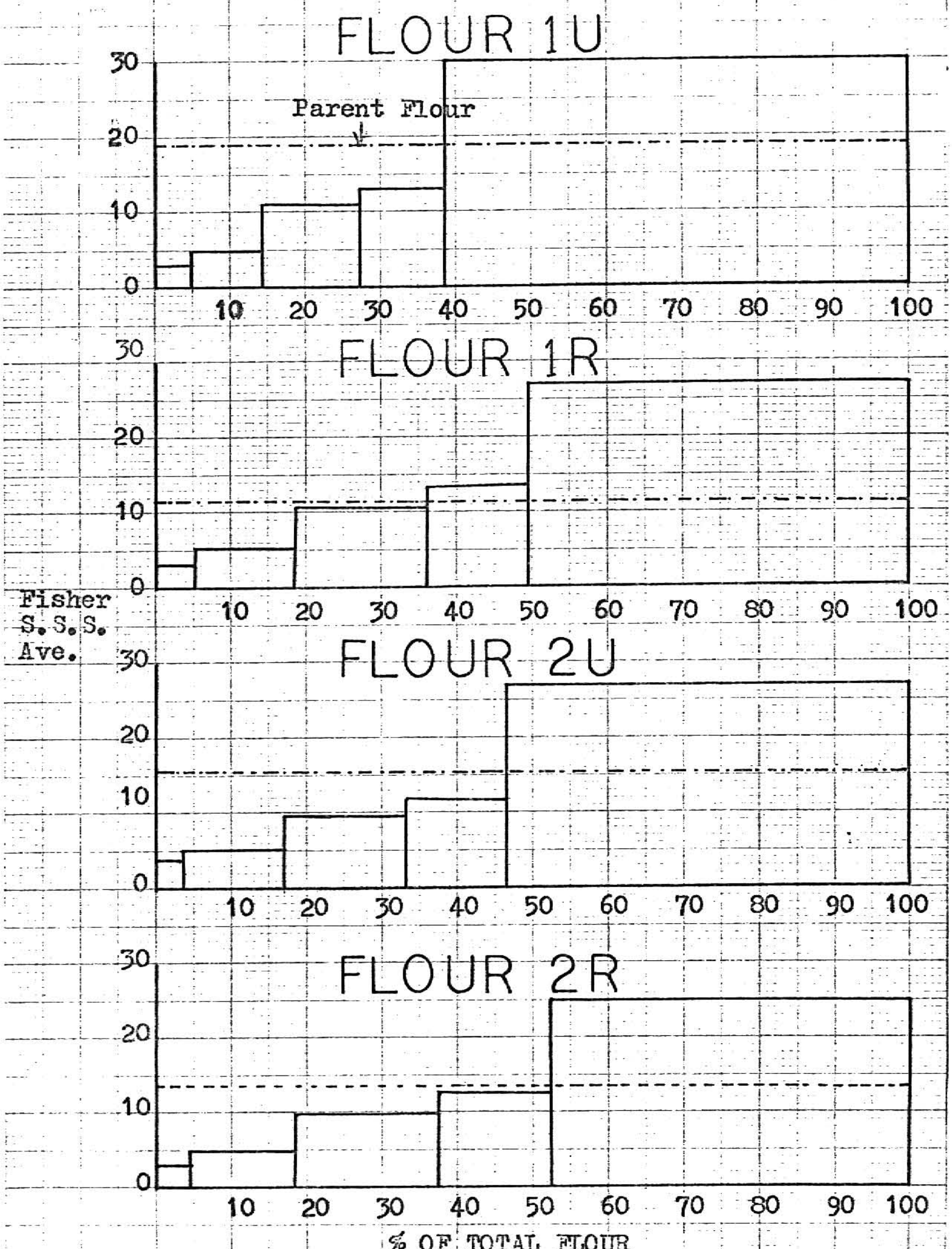


Figure 10 Air-Classified Flour Fractions

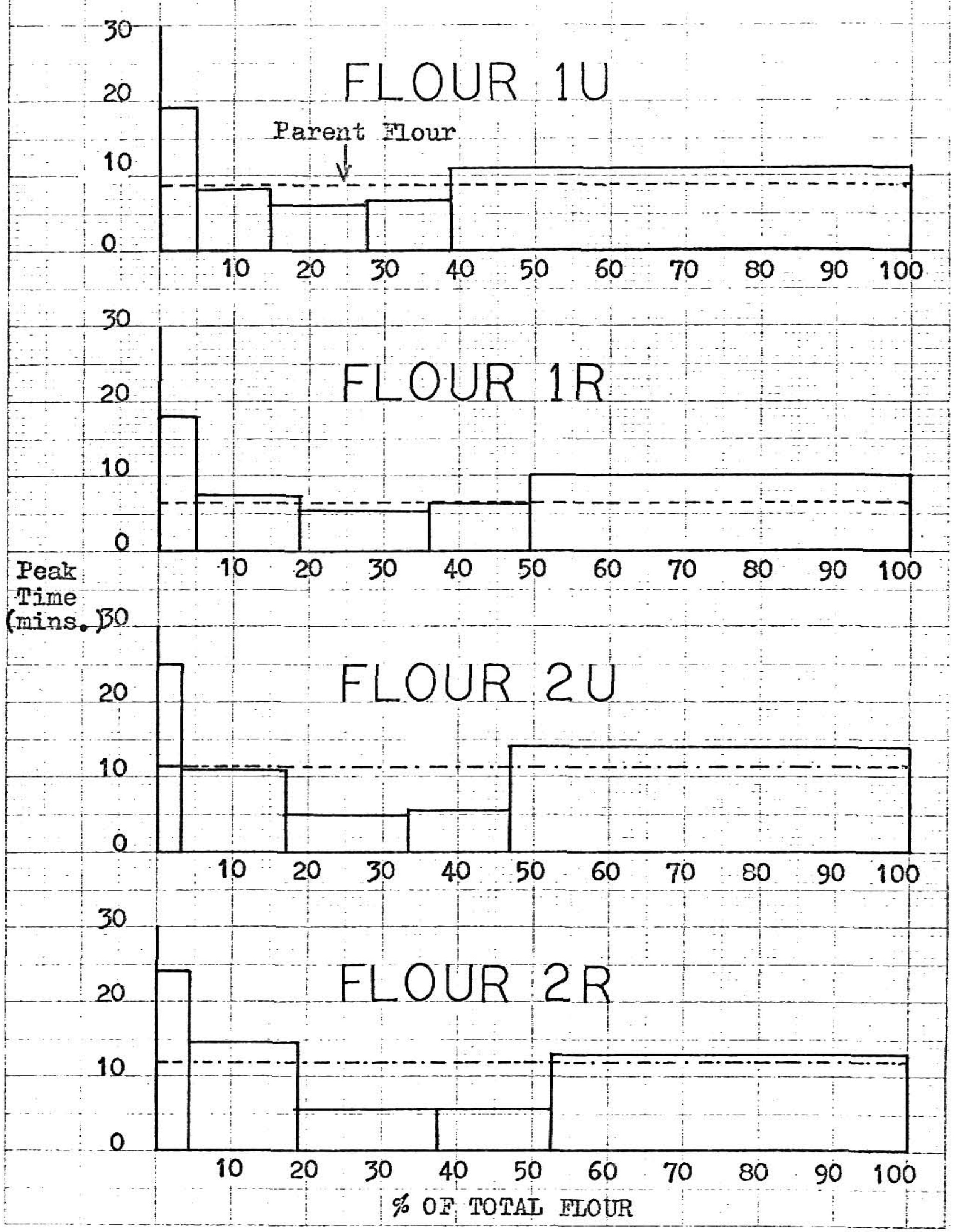
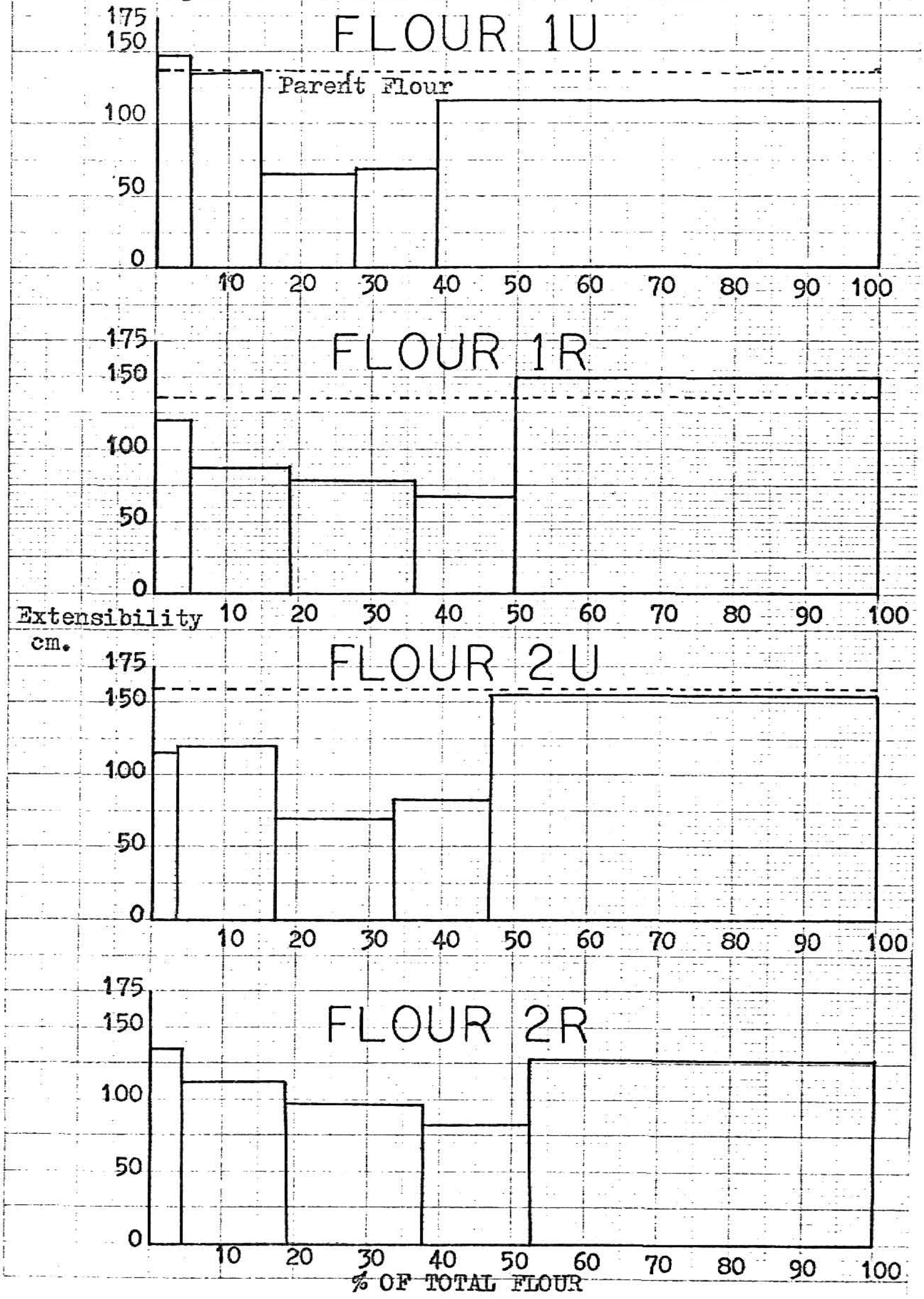


Figure 11 Air-Classified Flour Fractions



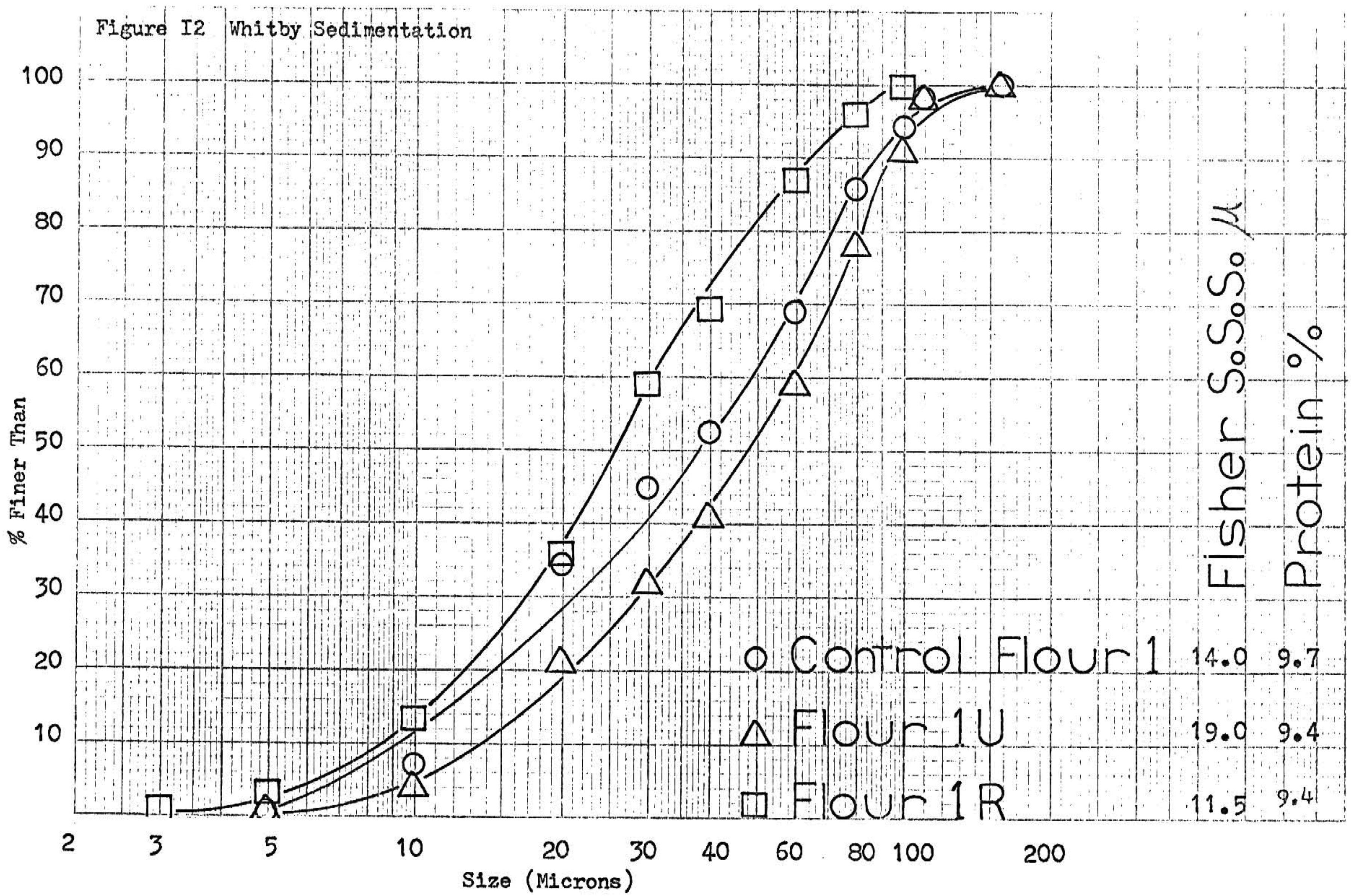


Figure I2 Whitby Sedimentation
% Finer Than
100
90
80
70
60
50
40
30
20
10
2
3
5
10
20
30
40
60
80
100
200
Size (Microns)
Fisher S.S.S. μ
Protein %
○ Control Flour 1 14.0 9.7
△ Flour 1U 19.0 9.4
□ Flour 1R 11.5 9.4

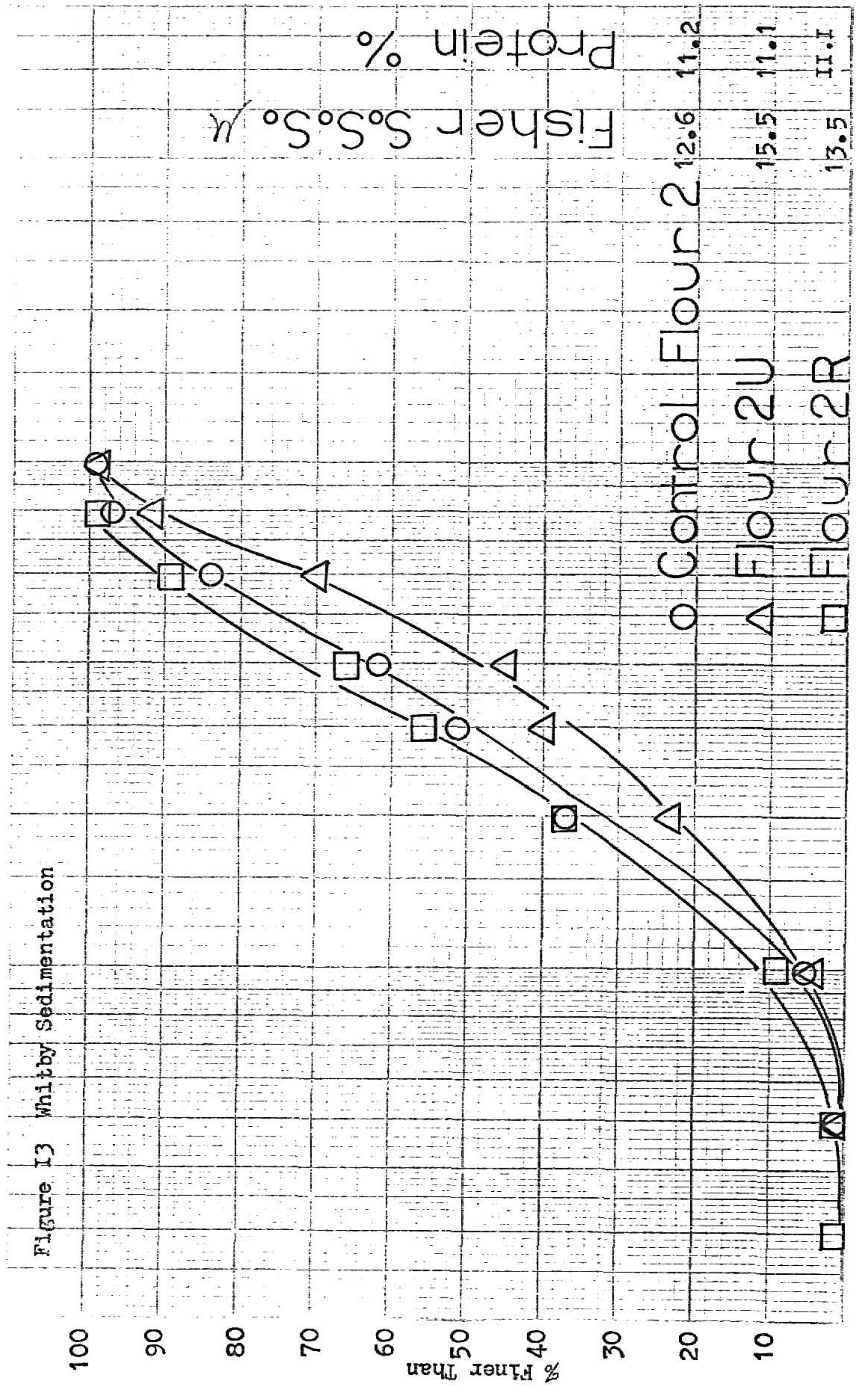
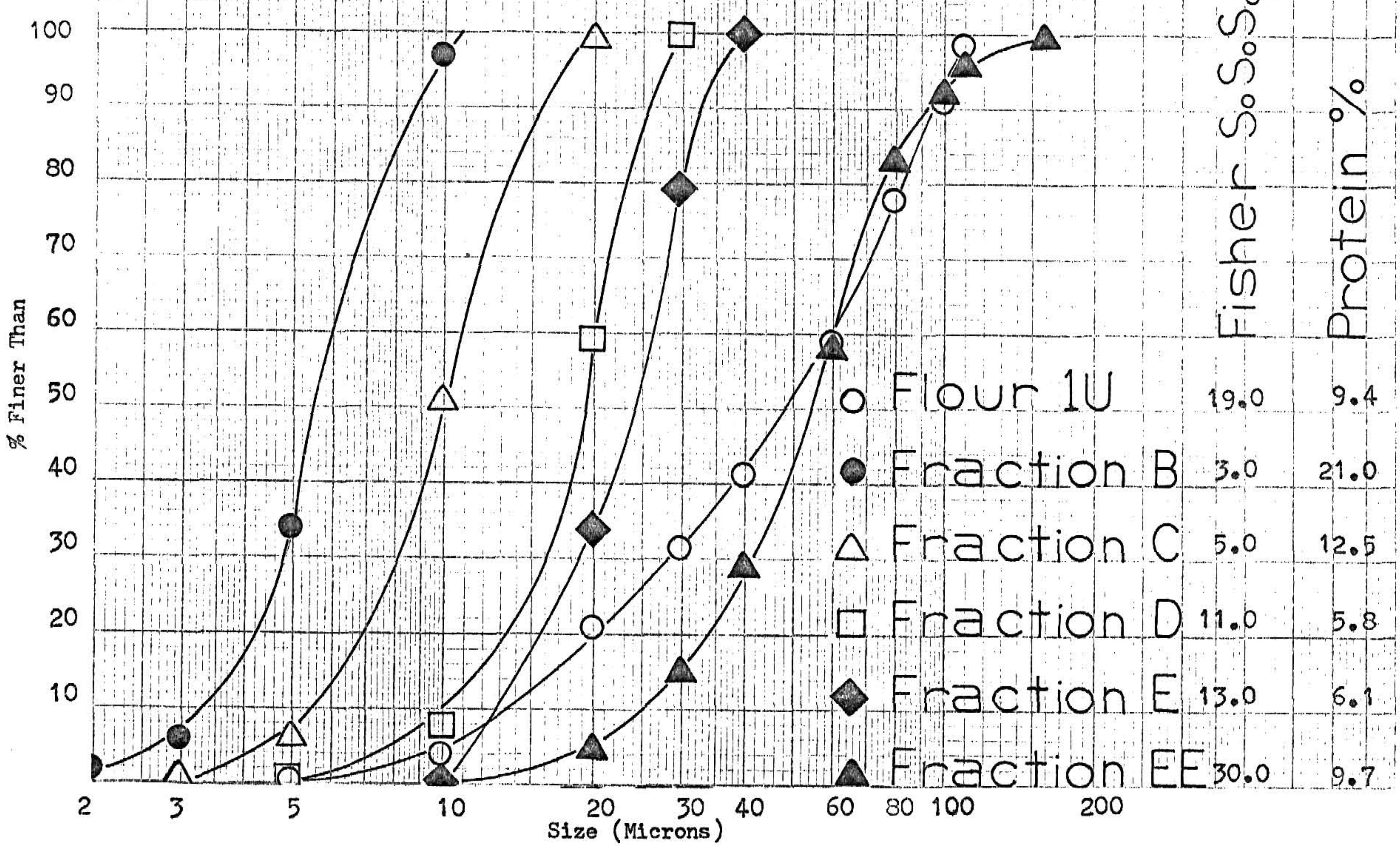


Figure 13 Whitby Sedimentation

Figure I4 Whitby Sedimentation



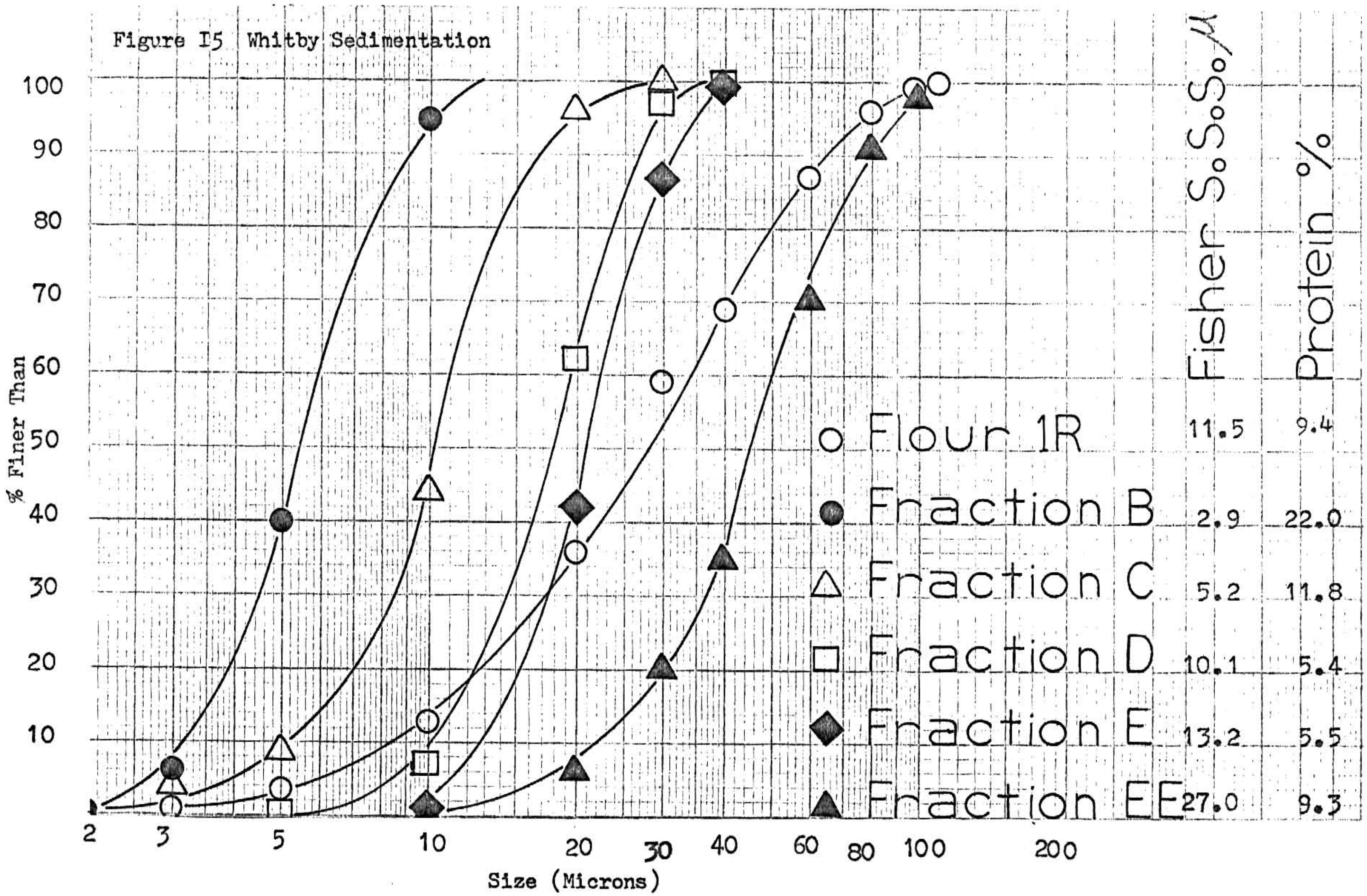


Figure I5 Whitby Sedimentation
100
90
80
70
60
50
40
30
20
10
% Finer Than
2
3
5
10
20
30
40
60
80
100
200
Size (Microns)
Fisher S.S.S.μ
Protein %
Flour 1R 11.5 9.4
Fraction B 2.9 22.0
Fraction C 5.2 11.8
Fraction D 10.1 5.4
Fraction E 13.2 5.5
Fraction EE 27.0 9.3

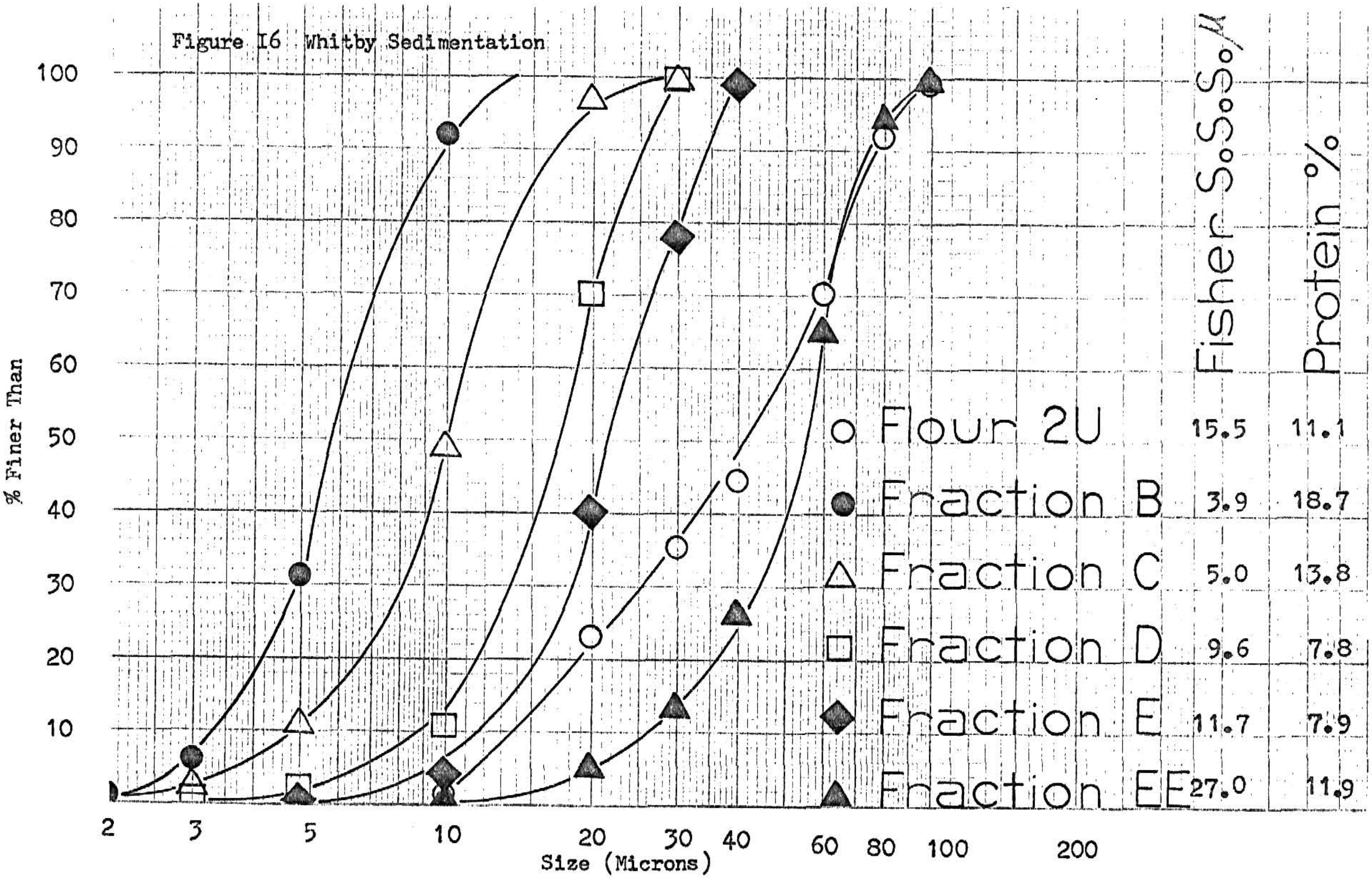


Figure 16 Whitby Sedimentation
% Finer Than
100
90
80
70
60
50
40
30
20
10
2
3
5
10
20
30
40
60
80
100
200
Size (Microns)
Fisher S.S.S. μ
Protein %
Flour 2U 15.5 11.1
Fraction B 3.9 18.7
Fraction C 5.0 13.8
Fraction D 9.6 7.8
Fraction E 11.7 7.9
Fraction EE 27.0 11.9

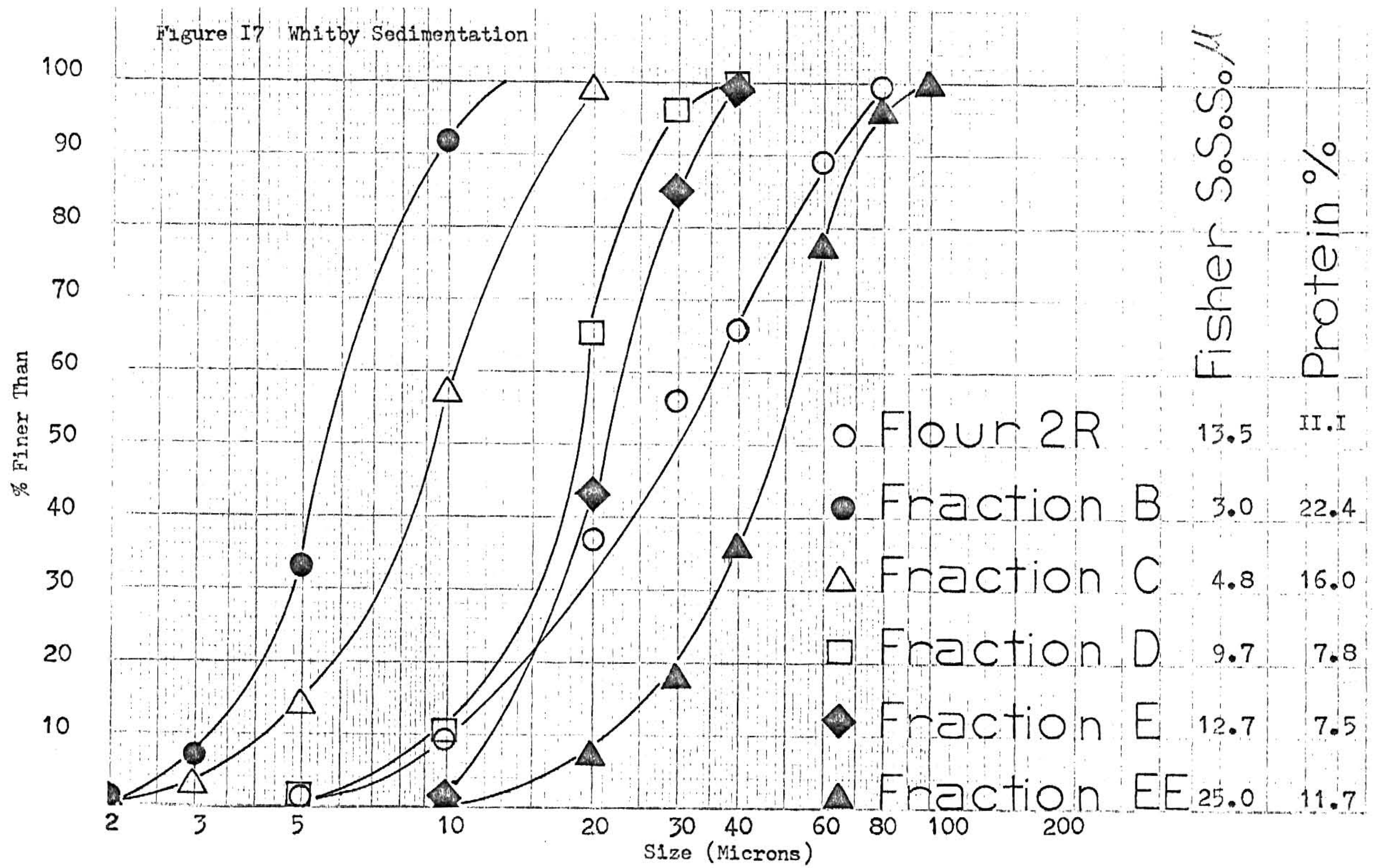


Figure I7 Whitby Sedimentation

The protein content of these fractions was higher than the parent flour. The protein content of D and E fractions was lower than that of the parent flour. The coarsest fraction (EE) had a protein content similar to that of the parent stock. High protein was associated with high ash and low protein was associated with low ash. The average particle size increased with each successive air-separation stage. As protein content increased from E, D, C to B fraction, the particle size decreased. Fractions of flour 1 U and 1 R with higher protein and ash content (B, C) showd higher color readings than in the low protein, low ash and chunk fractions. Fractions of flour 2 U and 2 R with higher protein and ash content (B, C), showed lower color readings than in the low protein, low ash and chunk fractions, except for fraction B of flour 2 R.

Viscocity was higher in the high protein fractions than in the low protein and chunk fractions mainly because of the protein content, but there was also an influence of ash content of the fractions.

The farinograms for the parent and flour fractions as shown in Figures 18, 19, 20 and 21 indicate the long peak mixing time was associated with high protein for the higher the protein the longer the mixing time. Mixing tolerance and water absorption increased with the protein content, but the mixing tolerance index (M.T.I.) decreased with increasing protein content. Farinograms also show influence of soft and hard wheats on flour for low protein content fractions and combinations, they show a long peak time characteristic of a

Figure I8 Farinograms of Control Flour I, Flour IU, and Fractions of Flour IU.

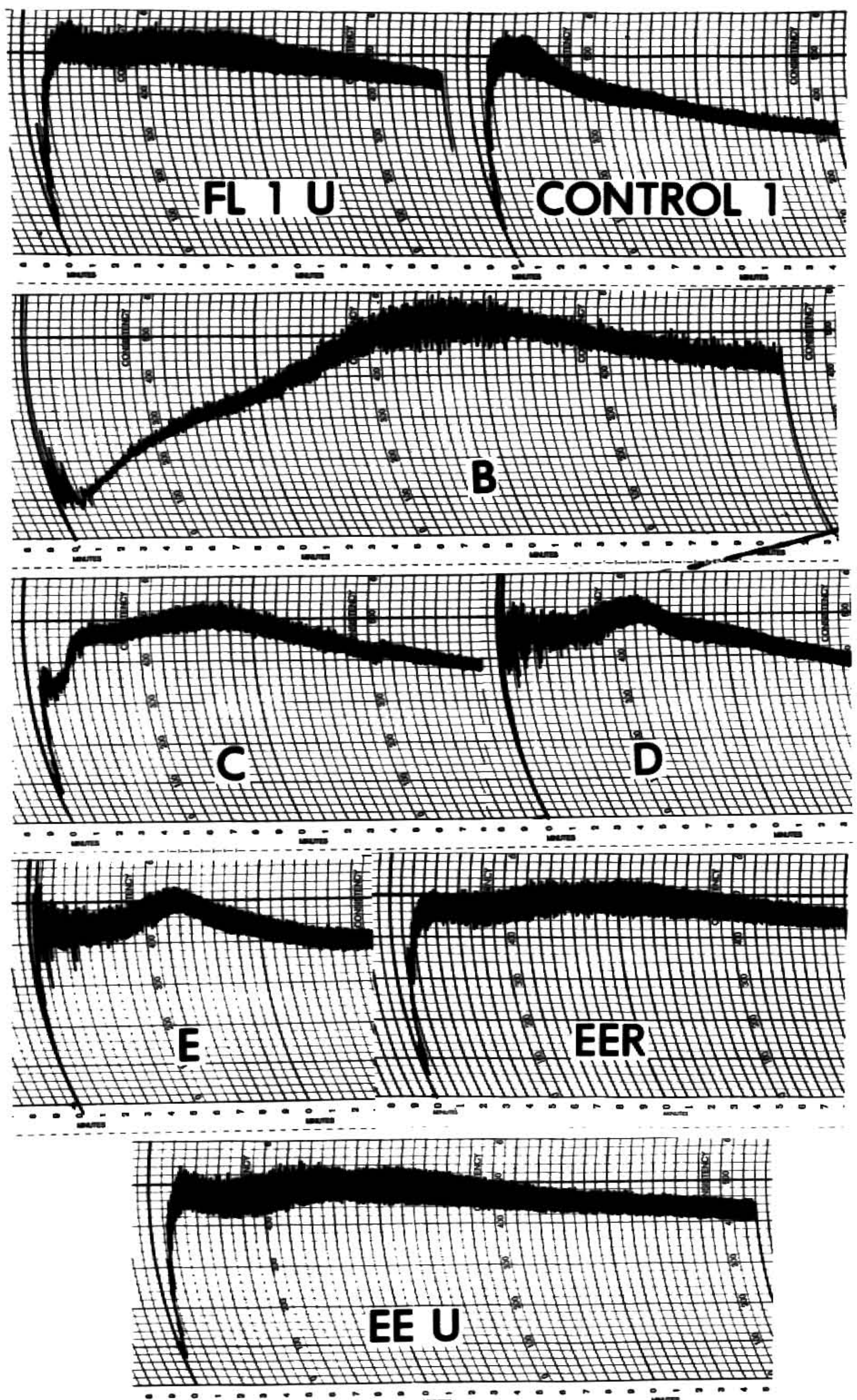


Figure I9 Farinograms of Flour IR, and Fractions of Flour IR.

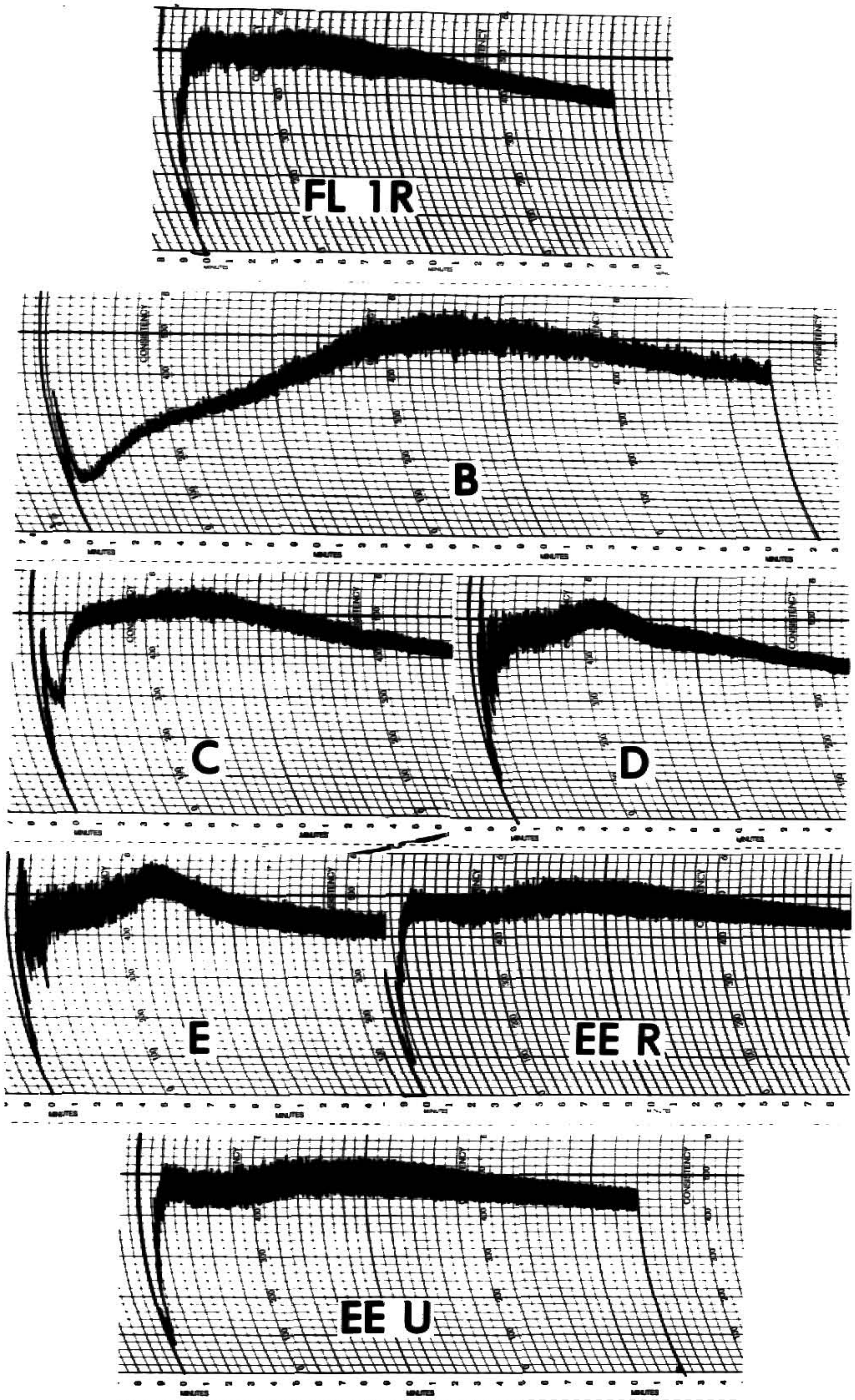


Figure 20 Farinograms of Control Flour 2, Flour 2U, and Fractions of Flour 2U.

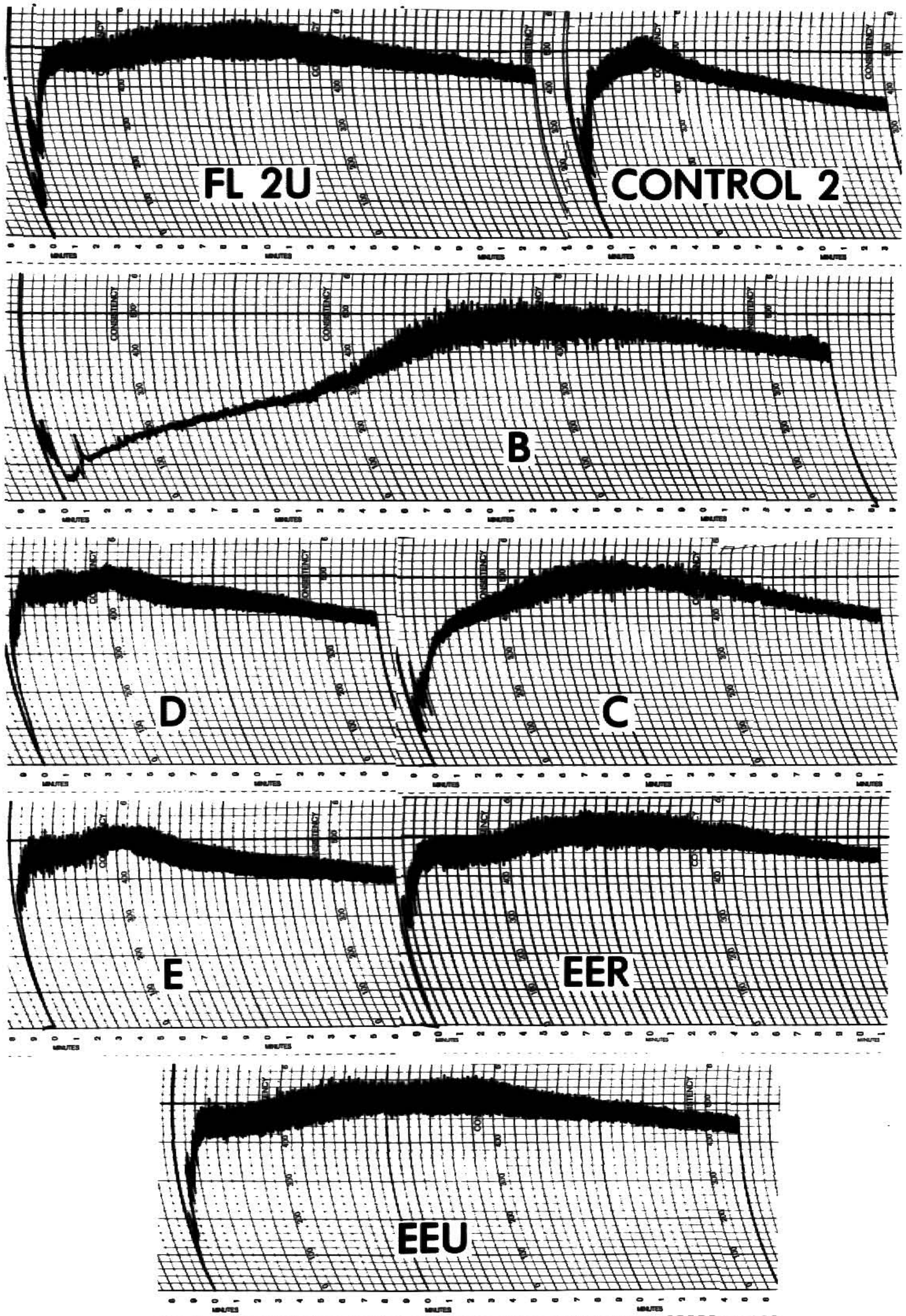
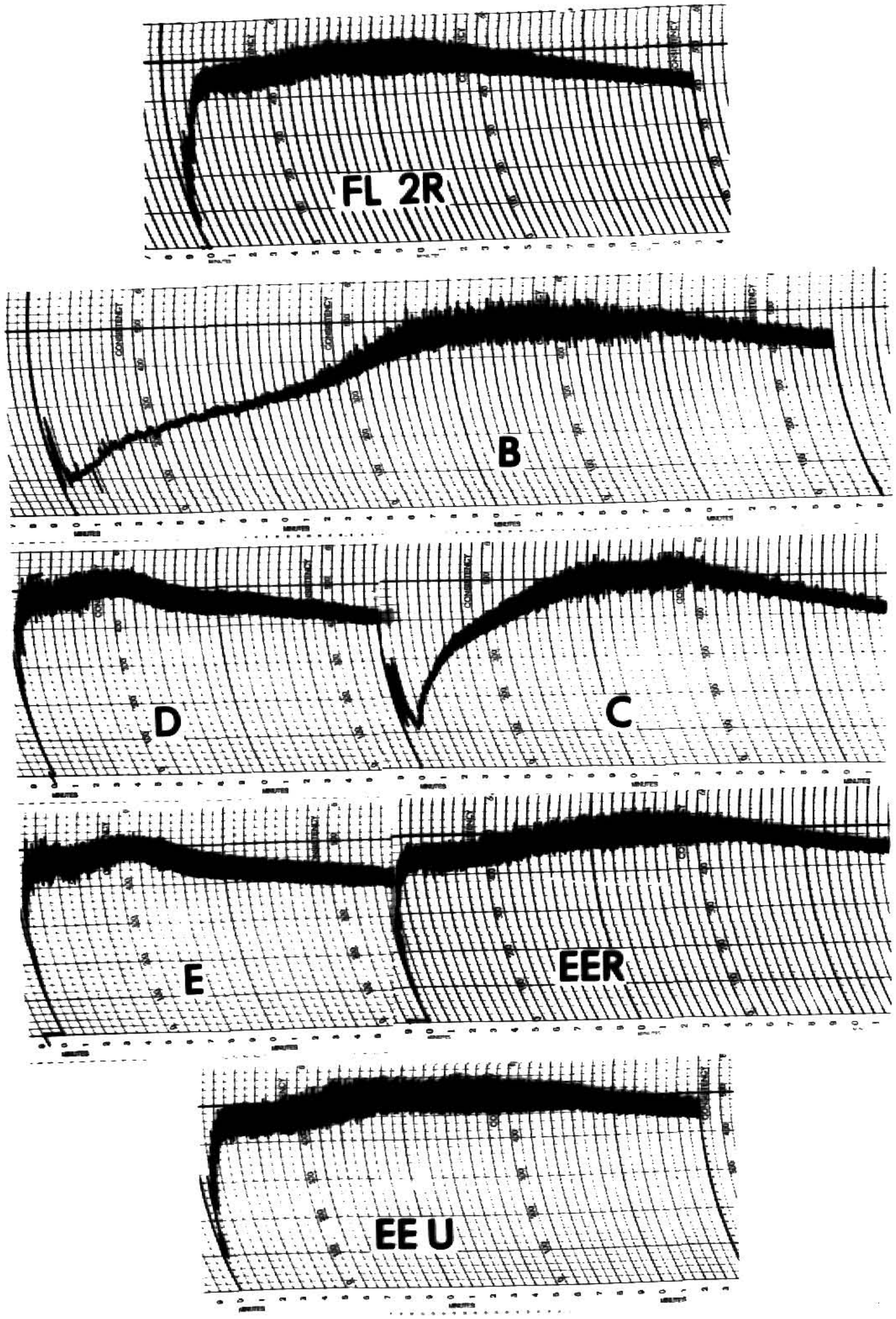


Figure 2I Farinograms of Flour 2R, and Fractions of Flour 2R.



soft wheat flour.

The extensograms for the parent and flour fractions, as shown in Figures 22, 23, 24 and 25 indicated the high protein content and chunk fractions had almost the same resistance to extension and extensibility but the resistance to extension of all these fractions was higher than that of the low protein fractions. It can be seen form tables 5, 6, 7 and 8 that even though there was a difference in resistance to extension and in extensibility among the fractions, the relation R/E (Resistance to Extension over Extensibility) was almost the same for all the fractions. Extensograms also show that the shape of the curve in the low protein fraction was very much the same as the shape of the curve of the parent flour. The relation R/E and shape of the extensogram curves for low protein fractions mean that the breakdown in protein content by air classification was not enough in this case, probably because of protein quality.

Particle size distribution curves from Figures 14, 15, 16 and 17 indicate that almost 90% of the flour for fraction D and E for all the flour samples was between 10 and 40 microns as specified for a starchy fraction, even though quality of the flour was not similar in any way to a soft wheat flour.

Analytical data of blends are shown in Tables 9, 10, 11 and 12. The farinograms for blends of fractions of the four flours as shown in Figures 26, 27, 28 and 29 indicated that long mixing time, high valorimeter value and low M.T.I. was associated with high protein content.

Figure 22 Extensograms of Control Flour 1 , Flour 1U, and Fraction Combinations of Flour 1U.

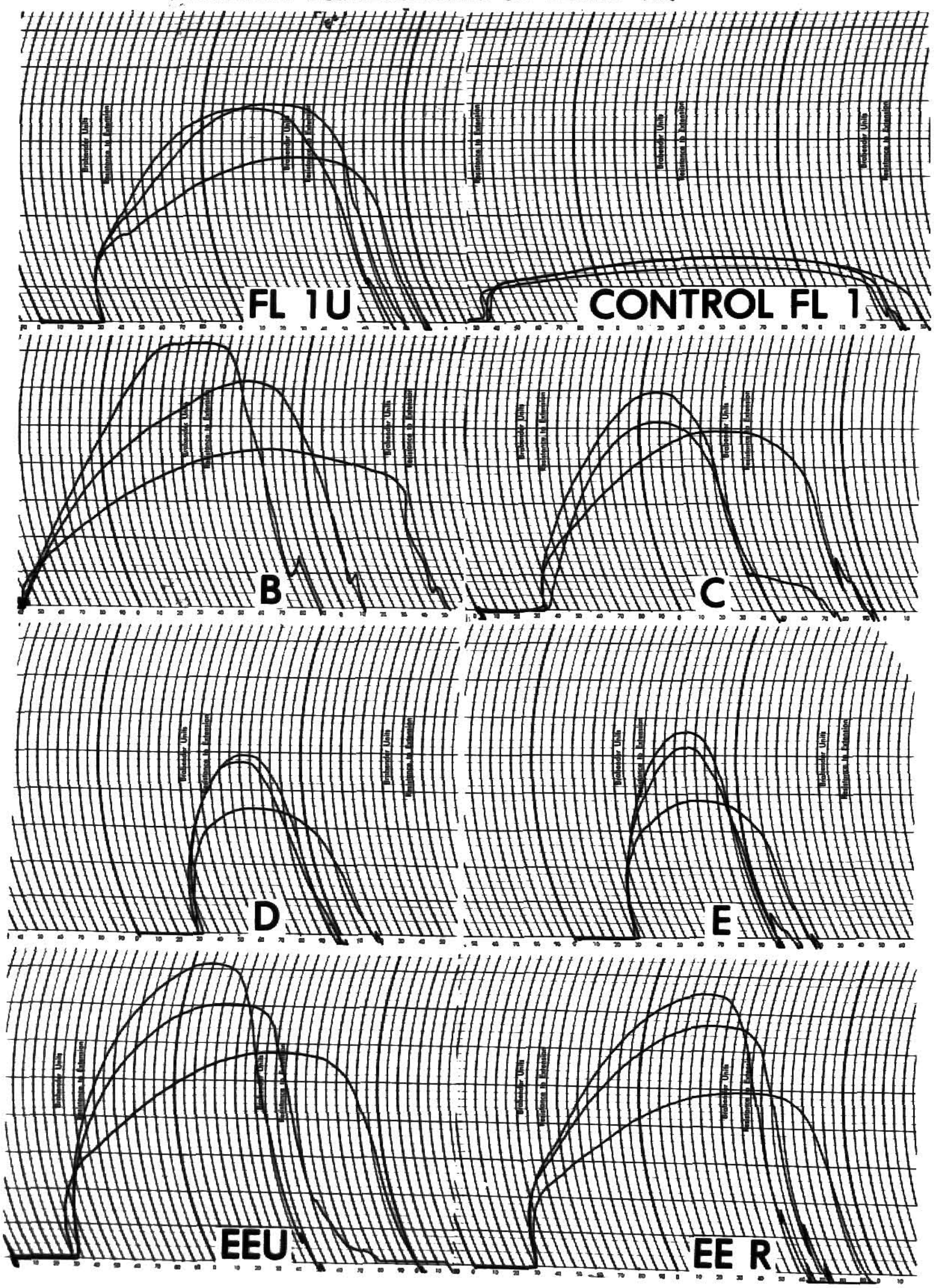


Figure 23 Extensograms of Flour IR, and Fractions of Flour IR

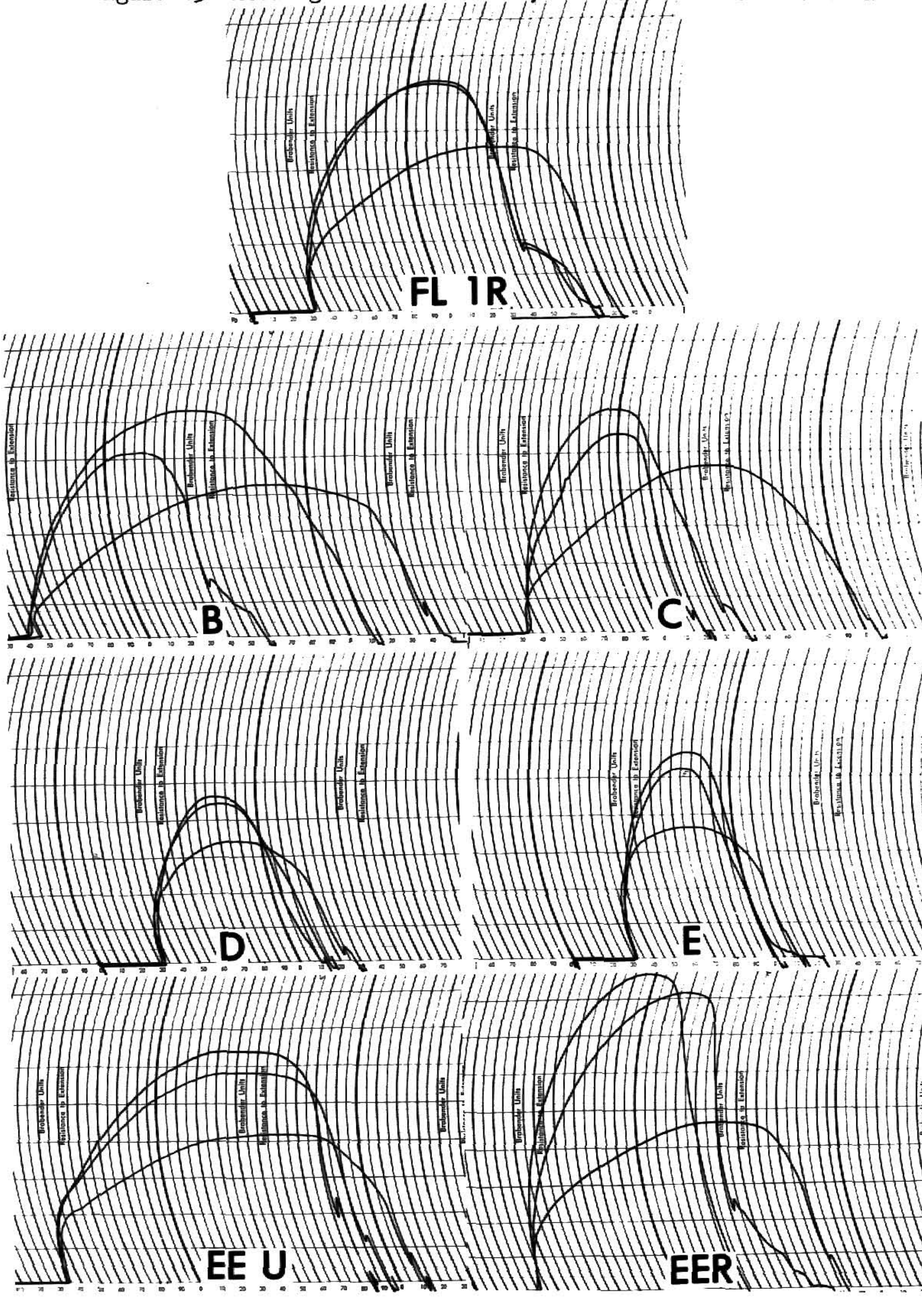


Figure 24 Extensograms of Control Flour 2, Flour 2U, and Fractions of Flour 2U.

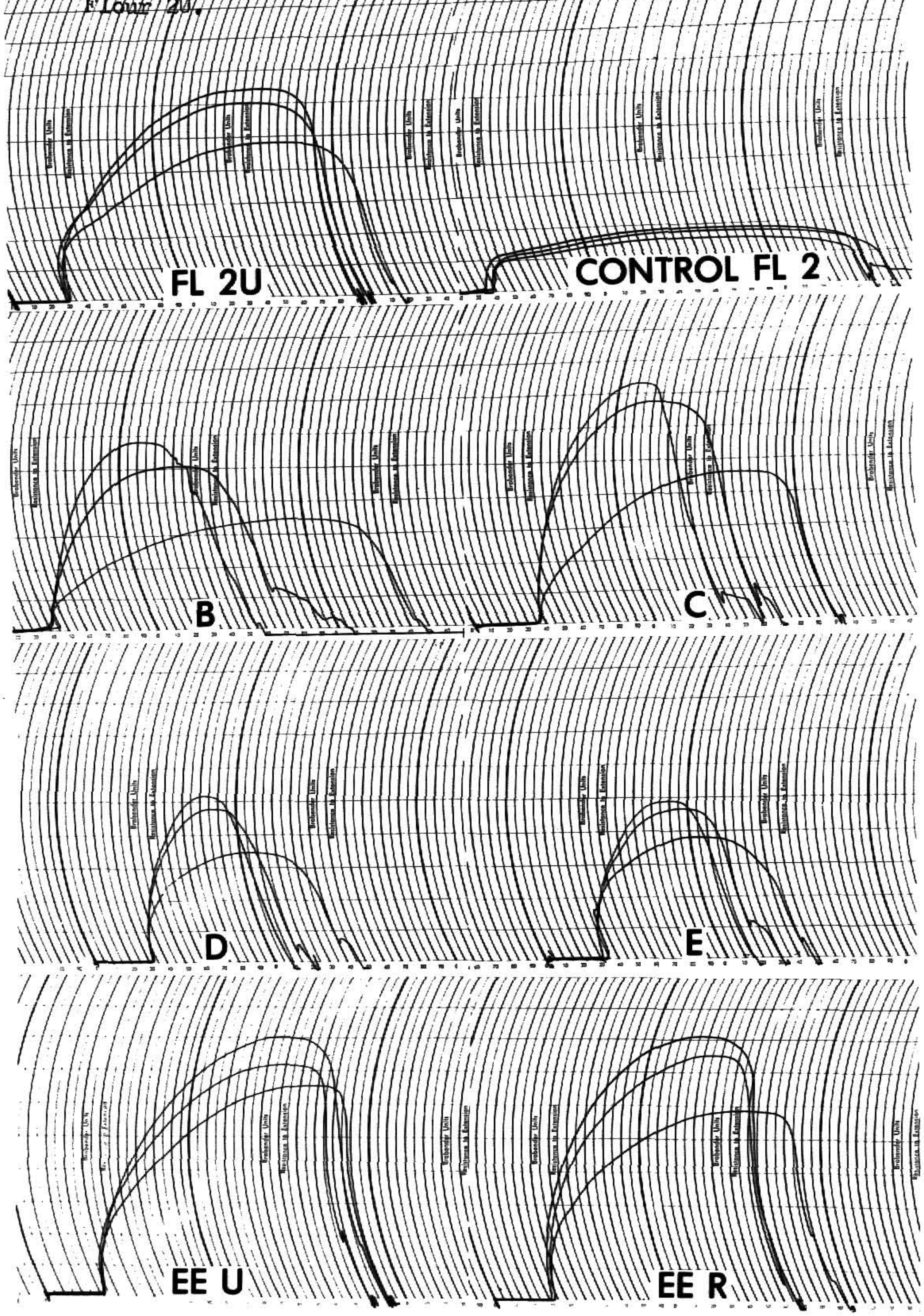


Figure 25 Extensograms of Flour 2R, and Fractions of Flour 2R.

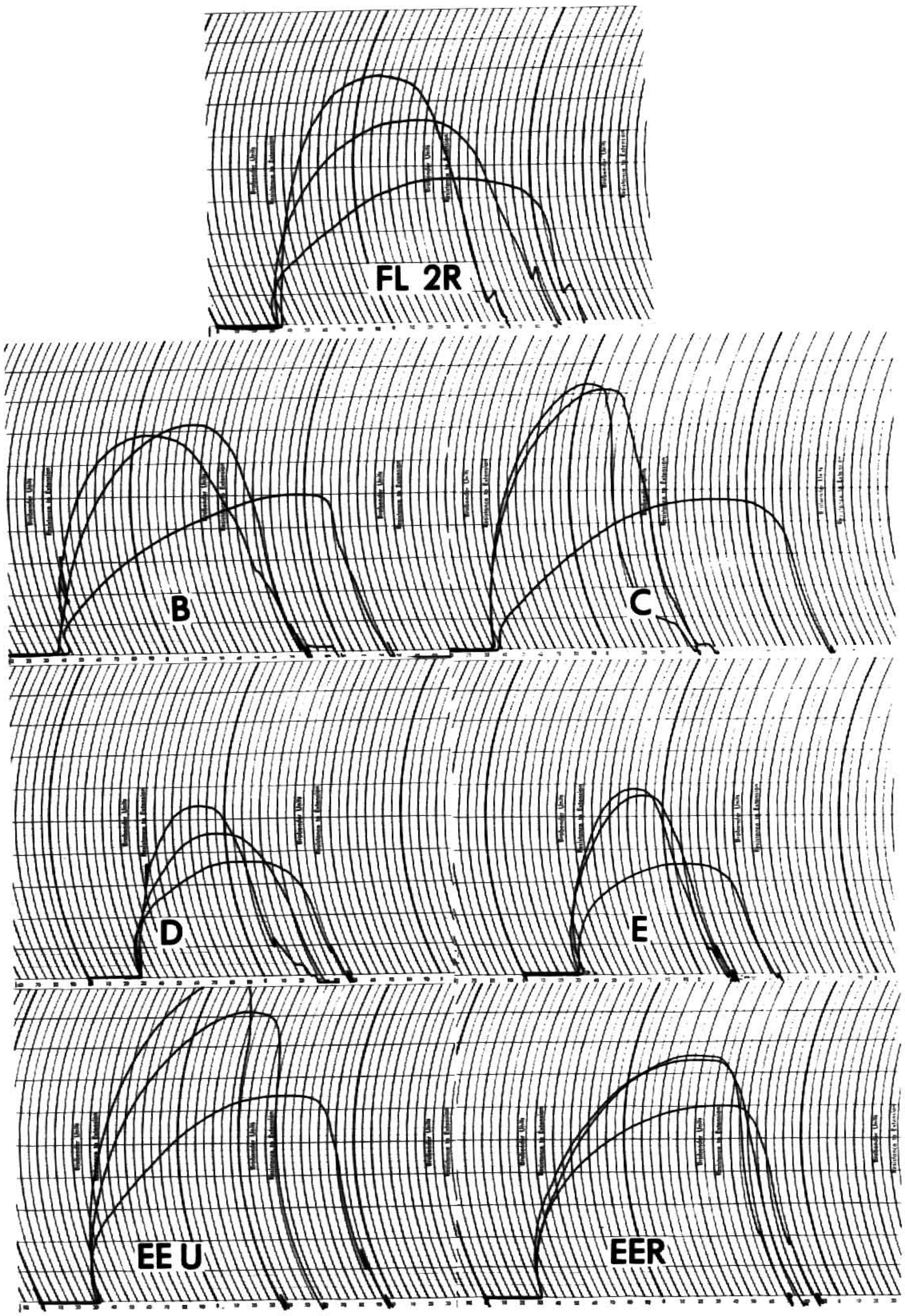


Table IX Quality Characteristics of Flour IU Fraction Combinations.

COMBINATIONS	PROTEIN* %	ASH* %	FISHER S.S.S. Microns	COLOR KENT JONES	ABSORPTION %	VALORIMETER B.U.	M T I	PEAKTIME Mins.
D,E 6.I4 % P	6.I4	0.42	II.50	I.95	6I.60	60.00	80.00	6.50
D,E,EE LF	6.37	0.42	I3.00	2.50	6I.20	59.00	80.00	6.50
D,E,C 8.0 % P	8.00	0.46	9.800	2.I0	65.00	53.00	70.00	5.50
D,E,EE 8.0 % P LF	8.00	0.42	I4.50	2.20	63.20	62.00	60.00	6.00
D,E,EE 8.0 % P	8.00	0.42	20.30	2.00	60.20	6I.00	70.00	6.50
D,E,C 9.6 % P	9.60	0.49	8.00	3.20	7I.40	53.00	60.00	6.00
D,E,EE 9.6 % P LF	9.60	0.4I	I4.00	2.30	64.20	70.00	40.00	9.00
D,E,EE 9.6 % P	9.60	0.4I	28.00	2.35	60.30	67.00	35.00	8.00
B,C,EE II.I4 % P	II.I4	0.45	28.00	4.20	65.00	76.00	40.00	I0.00
B,C,EE I2.5 % P	I2.50	0.50	22.00	5.00	7I.40	74.00	65.00	9.50

* Reported on I4.00% M.B.

Table X Quality Characteristics of Flour IR Fraction Combinations.

COMBINATIONS	PROTEIN* %	ASH* %	FISHER S.S.S. Microns	COLOR KENT JONES	ABSORPTION %	VALORIMETER B.U.	M T I	PEAKTIME Mins.
D,E 5.6 % P	5.60	0.4I	I2.I0	I.30	6I.40	58.00	70.00	5.50
D,E,EE LF	6.00	0.4I	I3.00	I.40	62.00	56.00	I00.00	5.50
D,E,C 8.0 % P	8.00	0.47	8.20	2.30	68.00	50.00	65.00	5.00
D,E,EE 8.0 % P LF	8.00	0.40	I5.00	I.70	63.60	62.00	50.00	7.50
D,E,EE 8.0 % P	8.00	0.40	I8.00	I.70	60.60	6I.00	50.00	7.00
D,E,C 9.0 % P	9.00	0.50	7.20	3.50	72.20	53.00	55.00	6.00
D,E,EE 9.0 % P LF	9.00	0.39	I4.00	2.20	64.40	67.00	40.00	8.00
D,E,EE 9.0 % P	9.00	0.39	22.I0	2.20	60.00	73.00	40.00	9.00
B,C,EE II.43 % P	II.43	0.45	I9.00	4.40	65.60	74.00	40.00	I0.00
B,C,EE I2.5 % P	I2.50	0.5I	I7.00	4.70	72.00	75.00	60.00	I0.00

*Reported on I4.00 % M.B.

Table XI Quality Characteristics of Flour 2U Fraction Combinations.

COMBINATIONS	PROTEIN* %	ASH* %	FISHER S.S.S. Microns	COLOR KENT JONES	ABSORPTION %	VALORIMETER B.U.	M T I	PEAKTIME Mins.
D,E 8.I % P	8.I0	0.70	I0.80	6.40	62.80	57.00	60.00	6.50
D,E,EE LF	8.96	0.69	I4.00	6.35	62.80	59.00	45.00	6.50
D,E,C 9.5 % P	9.50	0.74	8.75	6.52	66.00	60.00	40.00	6.00
D,E,EE 9.5 % P LF	9.50	0.68	I5.54	6.83	64.20	65.00	40.00	6.50
D,E,EE 9.5 % P	9.50	0.68	20.00	6.83	6I.80	65.00	40.00	7.00
D,E,C II.3 % P	II.30	0.79	7.I2	6.80	70.60	69.00	55.00	8.00
D,E,EE II.3 % P LF	II.30	0.65	I5.80	6.95	66.20	80.00	35.00	I0.50
D,E,EE II.3 % P	II.30	0.65	22.00	6.90	63.20	77.00	30.00	I0.50
B,C,EE I2.5 % P	I2.50	0.66	23.20	6.50	65.00	80.00	50.00	II.00
B,C,EE I2.97 % P	I2.97	0.70	2I.00	6.40	68.00	85.00	40.00	I2.00

*Reported on I4.00 % M.B.

Table XII Quality Characteristics of Flour 2R Fraction Combinations.

COMBINATIONS	PROTEIN* %	ASH* %	FISHER S.S.S. Microns	COLOR KENT JONES	ABSORPTION %	VALORIMETER B.U.	M T I	PEAKTIME Mins.
D,E 7.9 % P	7.90	0.67	II.30	5.80	6I.80	60.00	60.00	6.00
D,E,EE LF	8.78	0.66	I4.00	6.20	62.20	62.00	55.00	5.50
D,E,C 9.5 % P	9.50	0.72	I0.50	6.20	65.00	6I.00	50.00	6.50
D,E,EE 9.5 % P LF	9.50	0.65	I4.50	6.90	64.40	68.00	30.00	7.00
D,E,EE 9.5 % P	9.50	0.65	I8.00	6.85	62.40	62.00	40.00	6.00
D,E,C I0.3 % P	I0.30	0.73	9.50	6.40	65.80	6I.00	35.00	6.50
D,E,EE I0.3 % P LF	I0.30	0.64	I3.60	7.00	65.00	76.00	30.00	I0.00
D,E,EE I0.3 % P	I0.30	0.64	2I.00	6.90	63.00	76.00	30.00	I0.00
B,C,EE I2.5 % P	I2.50	0.65	I9.00	7.50	64.60	85.50	30.00	I2.50
B,C,EE I3.78 % P	I3.78	0.72	I7.00	7.90	68.20	85.00	40.00	I3.00

*Reported on I4.00 % M.B.

Figure 26 Farinograms.

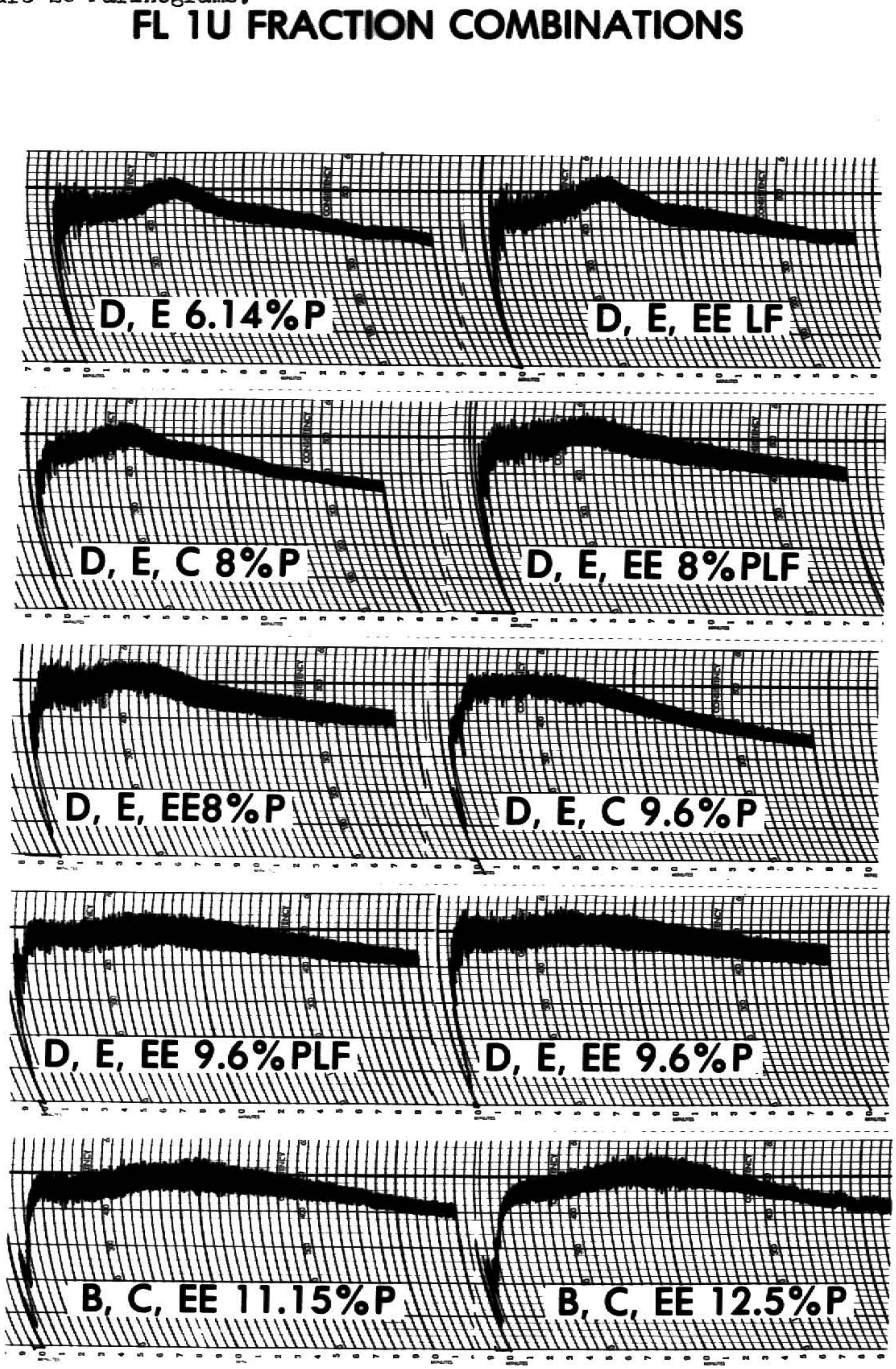


Figure 27 Farinograms.

FL 1R FRACTION COMBINATIONS

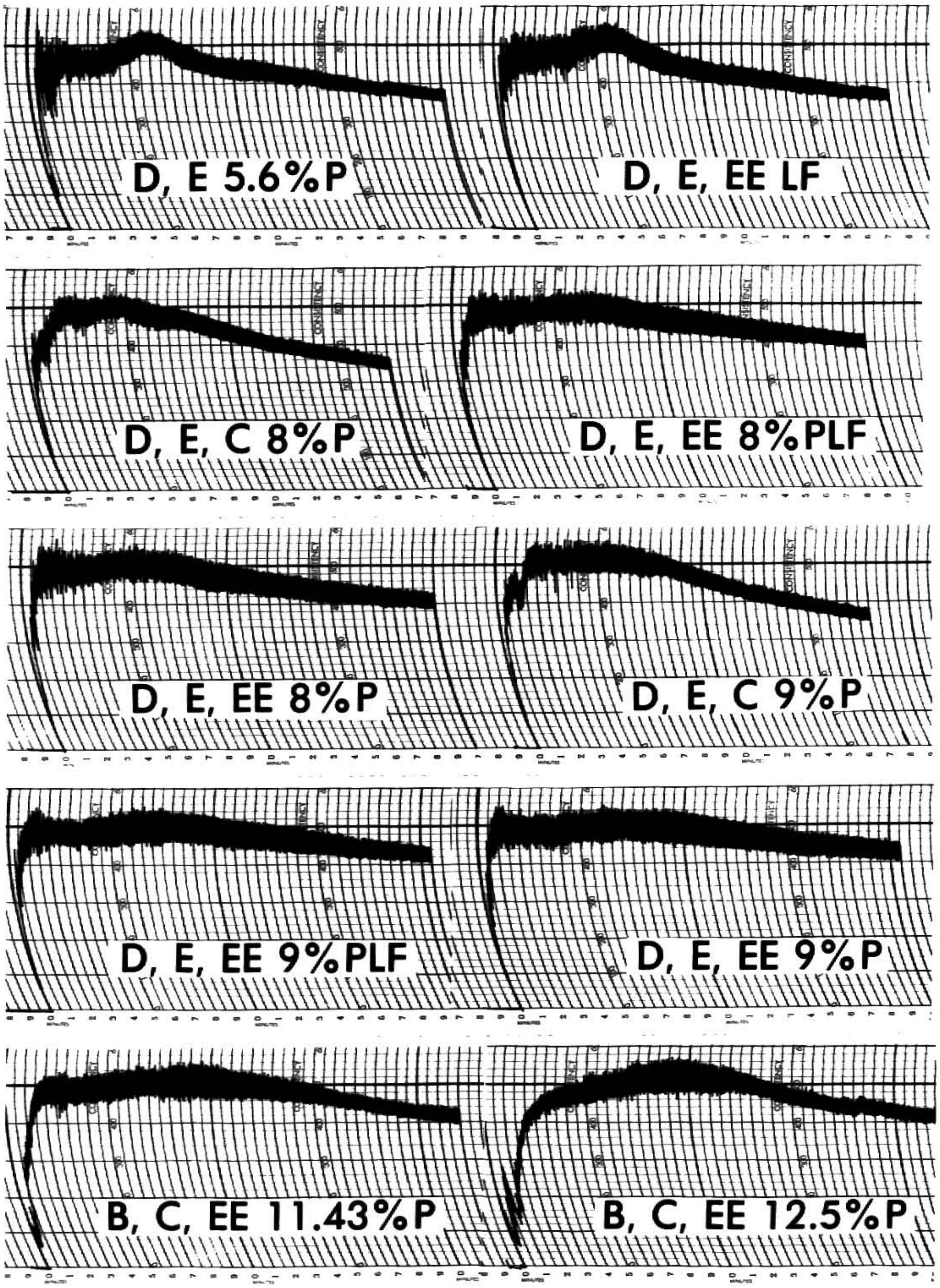


Figure 28 Farinograms.

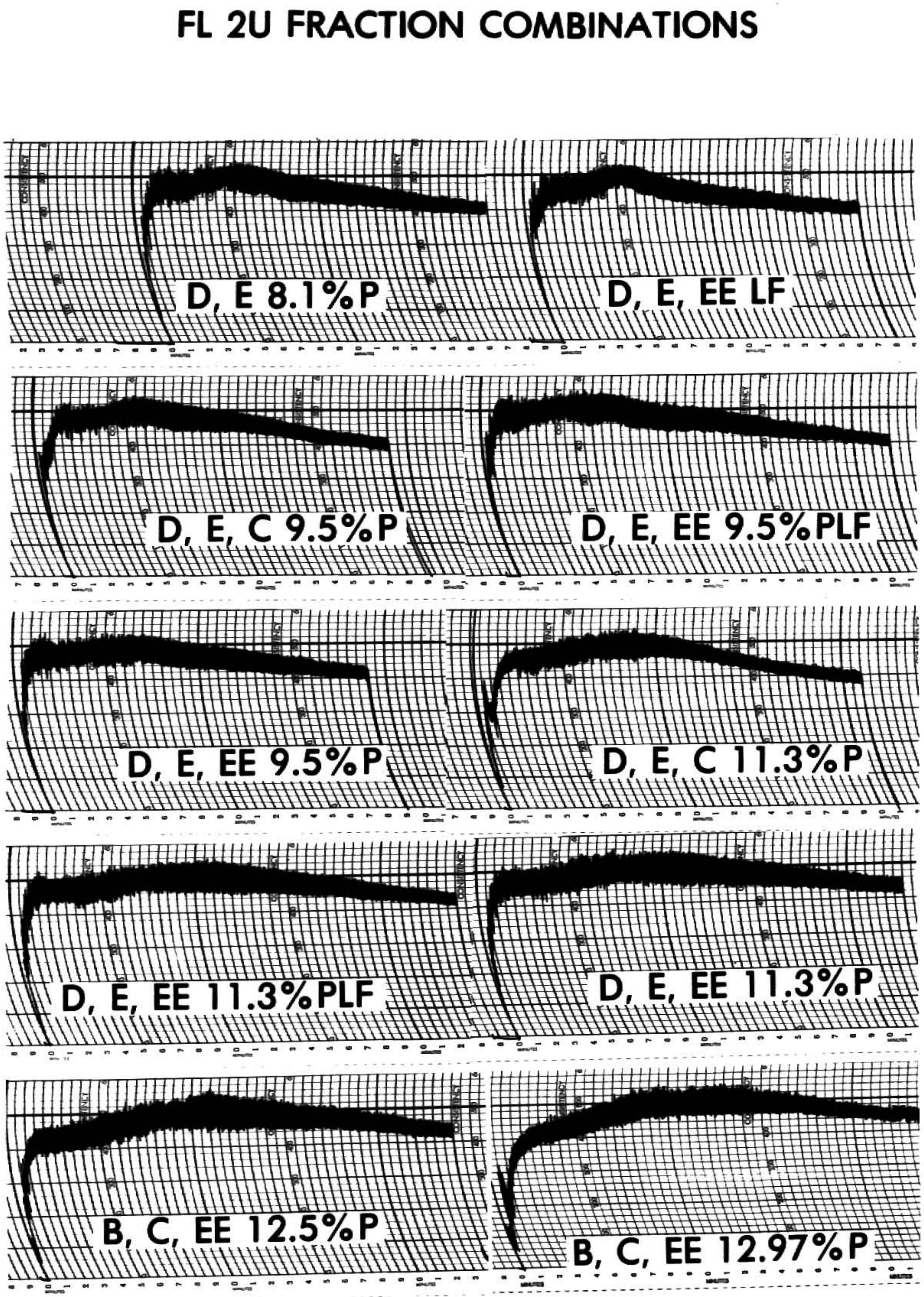
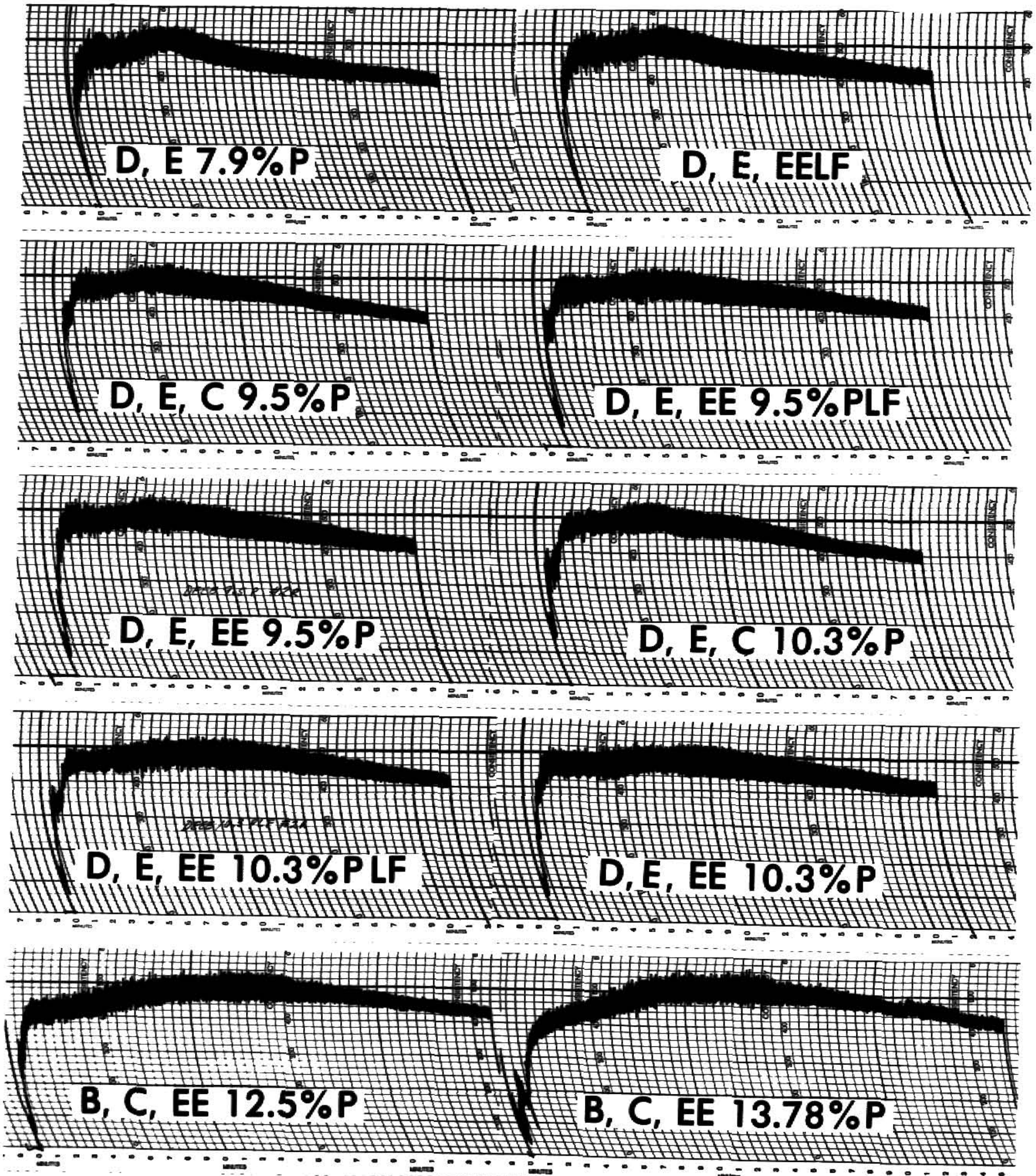


Figure 29 Farinograms,
FL 2R FRACTION COMBINATIONS



Baking data of control, parent and fractions of parent flours are shown in Tables 13, 14, 15 and 16. Figures 30, 31, 32 and 33 show that cookies made with flour with low average particle size were of poor quality even though protein content was of an acceptable level. It was also the same for parent and fraction EE when reground to lower the particle size. However, cookies made with flour blend of D, E, EE (EE Unground) fractions showed an increase in cookie quality as the protein and particle size increased. Fraction EE Unground of flour 1 U showed the largest average diameter among the fractions, however fraction EE Unground of flour 1 R showed the best cookie appearance. This indicates that a coarser cut in the air classification of this flour could render a flour with better cookie baking quality.

Figure 34 shows bread baked from parent and combination of B, C and EE fractions of the parent flours. It can be seen from this Figure that there was an increase in bread loaf volume as protein content of the blend increased.

Table 17 shows a linear correlation coefficient between analytical values determined from the fractions. It indicates that there was a better correlation between protein content and viscocity than between protein content and particle size, while protein content and particle size showed better correlation than viscocity and ash except for flour 1 Unground.

TABLE XIII

BAKING DATA OF FLOUR 1 UNGROUND AND FRACTION COMBINATIONS OF FLOUR 1 U

FLOUR OR FRACTION COMBINATION	COOKIE DIAMETER CM.	COOKIE SCORE	BREAD VOLUME C.C.	BREAD SCORE
Control Flour 1	9.42	8	-	-
Flour 1 Unground	8.88	5	2075	22
D,E 6.14% P	7.88	0	-	-
D,E,EE,LF	7.90	0	-	-
D,E,C 8.0% P	7.64	0	-	-
D,E,EE 8.0% P LF	8.08	0	-	-
D,E,EE 8.0% P	8.50	3	-	-
D,E,C 9.6% P	7.51	0	-	-
D,E,EE 9.6% P LF	8.21	0	-	-
D,E,EE 9.6% P	8.98	8	-	-
B,C,EE 11.14% P	-	-	2250	29
B,C,EE 12.5% P	-	-	2150	26
EE U	9.03	7	-	-
EE R	8.18	0	-	-

TABLE XIV

BAKING DATA OF FLOUR 1 REGROUND AND FRACTION COMBINATIONS OF FLOUR 1 R

FLOUR OR FRACTION COMBINATION	COOKIE DIAMETER CM.	COOKIE SCORE	BREAD VOLUME C.C.	BREAD SCORE
Flour 1 Reground	8.28	0	-	-
D,E 5.6% P	8.00	0	-	-
D,E,EE, LF	8.12	0	-	-
D,E,C 8.0% P	7.70	0	-	-
D,E,EE 8.0% P LF	8.22	0	-	-
D,E,EE 8.0% P	8.54	1	-	-
D,E,C 9.0% P	7.53	0	-	-
D,E,EE 9.0% P LF	8.25	0	-	-
D,E,EE 9.0% P	8.63	2	-	-
B,C,EE 11.43% P	-	-	2050.0	22
B,C,EE 12.5% P	-	-	2212.5	26
EE U	8.87	8	-	-
EE R	8.37	0	-	-

TABLE XV

BAKING DATA OF CONTROL FLOUR 2, FLOUR 2 UNGROUND AND FRACTION COMBINATIONS OF FLOUR 2 U

FLOUR OR FRACTION COMBINATION	COOKIE DIAMETER CM.	COOKIE SCORE	BREAD VOLUME C.C.	BREAD SCORE
Control Flour 2	9.07	7	-	-
Flour 2 Unground	8.71	2	2300	27
D,E 8.1% P	8.32	1	-	-
D,E,EE LF	8.38	1	-	-
D,E,C 9.5% P	8.08	0	-	-
D,E,EE 9.5% P LF	8.28	0	-	-
D,E,EE 9.5% P	8.60	6	-	-
D,E,C 11.3% P	7.88	0	-	-
D,E,EE 11.3% P LF	8.21	0	-	-
D,E,EE 11.3% P	8.68	8	-	-
B,C,EE 12.5% P	-	-	2600	30
B,C,EE 12.97% P	-	-	2425	28
EE U	8.54	0	-	-
EE R	8.11	0	-	-

TABLE XVI

BAKING DATA OF FLOUR 2 REGROUND AND FRACTION COMBINATIONS OF FLOUR 2 R

FLOUR OR FRACTION COMBINATION	COOKIE DIAMETER CM.	COOKIE SCORE	BREAD VOLUME C.C.	BREAD SCORE
Flour 2 Reground	7.86	0	-	-
D,E 7.9% P	8.43	0	-	-
D,E,EE,LF	8.57	0	-	-
D,E,C 9.5% P	8.31	0	-	-
D,E,EE 9.5% P LF	8.30	0	-	-
D,E,EE 9.5% P	8.67	3	-	-
D,E,C 10.3% P	8.21	0	-	-
D,E,EE 10.3% P LF	8.28	0	-	-
D,E,EE 10.3% P	8.77	7	-	-
B,C,EE 12.5% P	-	-	2350	25
B,C,EE 13,78% P	-	-	2500	30
EE U	8.63	3	-	-
EE R	8.23	0	-	-

TABLE XVII

LINEAR CORRELATION COEFFICIENT BETWEEN VARIOUS ANALYTICAL VALUE DETERMINED FOR FRACTION

	PROTEIN VS. VISCOSITY	PROTEIN VS. PARTICLE SIZE	VISCOSITY VS. ASH
Flour 1 U	0.995**	-0.61	0.95**
Flour 1 R	0.997**	-0.60	0.35
Flour 2 U	0.970**	-0.38	0.32
Flour 2 R	0.960**	-0.89**	0.42

** 1% level of significance.

Figure 30 Results of Cookie Baking on Control Flour I, Flour IU, and Fraction Combinatios of Flour IU.

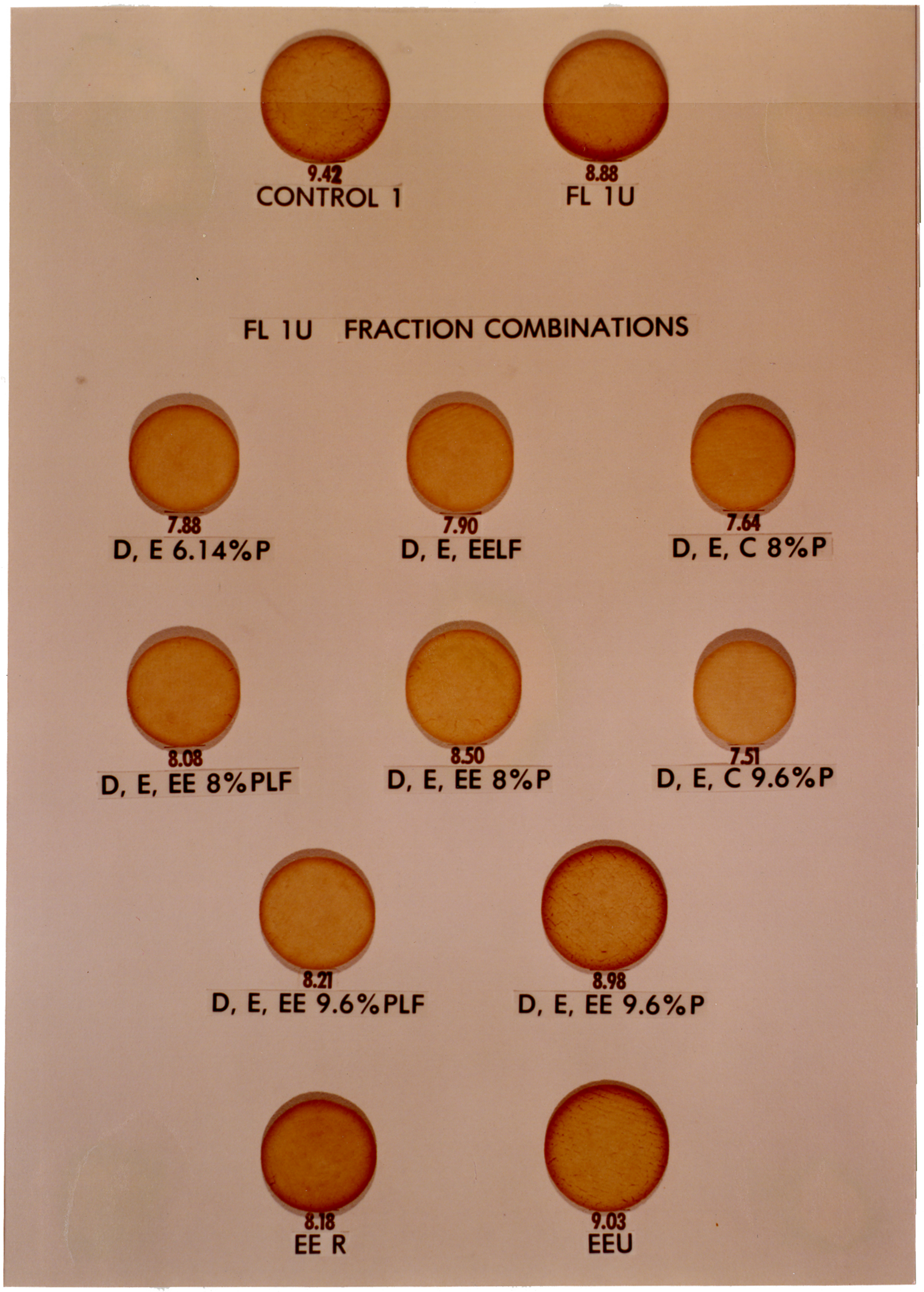


Figure 31 Results of Cookie Baking on Control Flour 1, Flour 1R, and Fraction Combinations of Flour 1R.

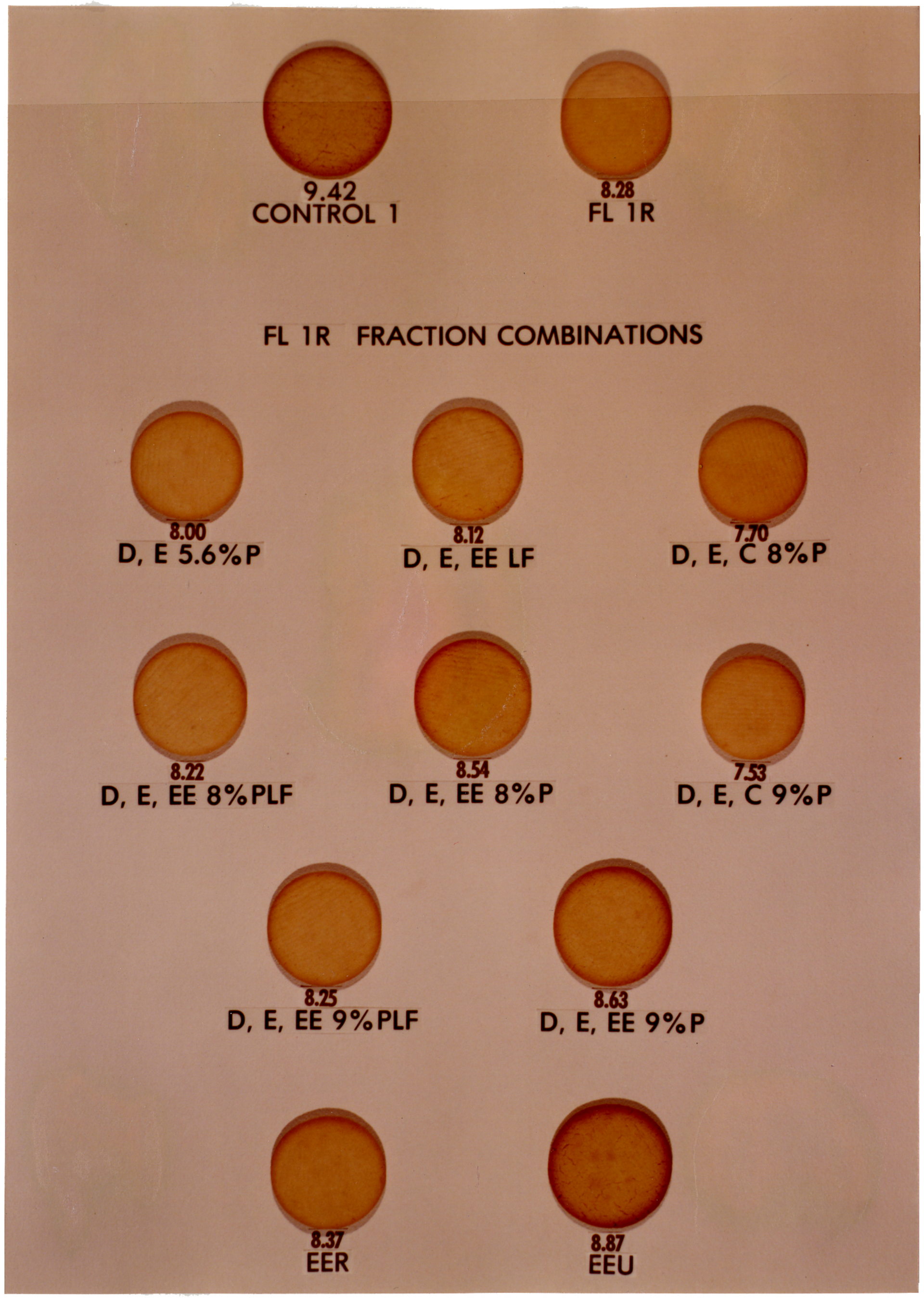


Figure 32 Results of Cookie Baking on Control Flour 2, Flour 2U, and Fraction Combinations of Flour 2U.

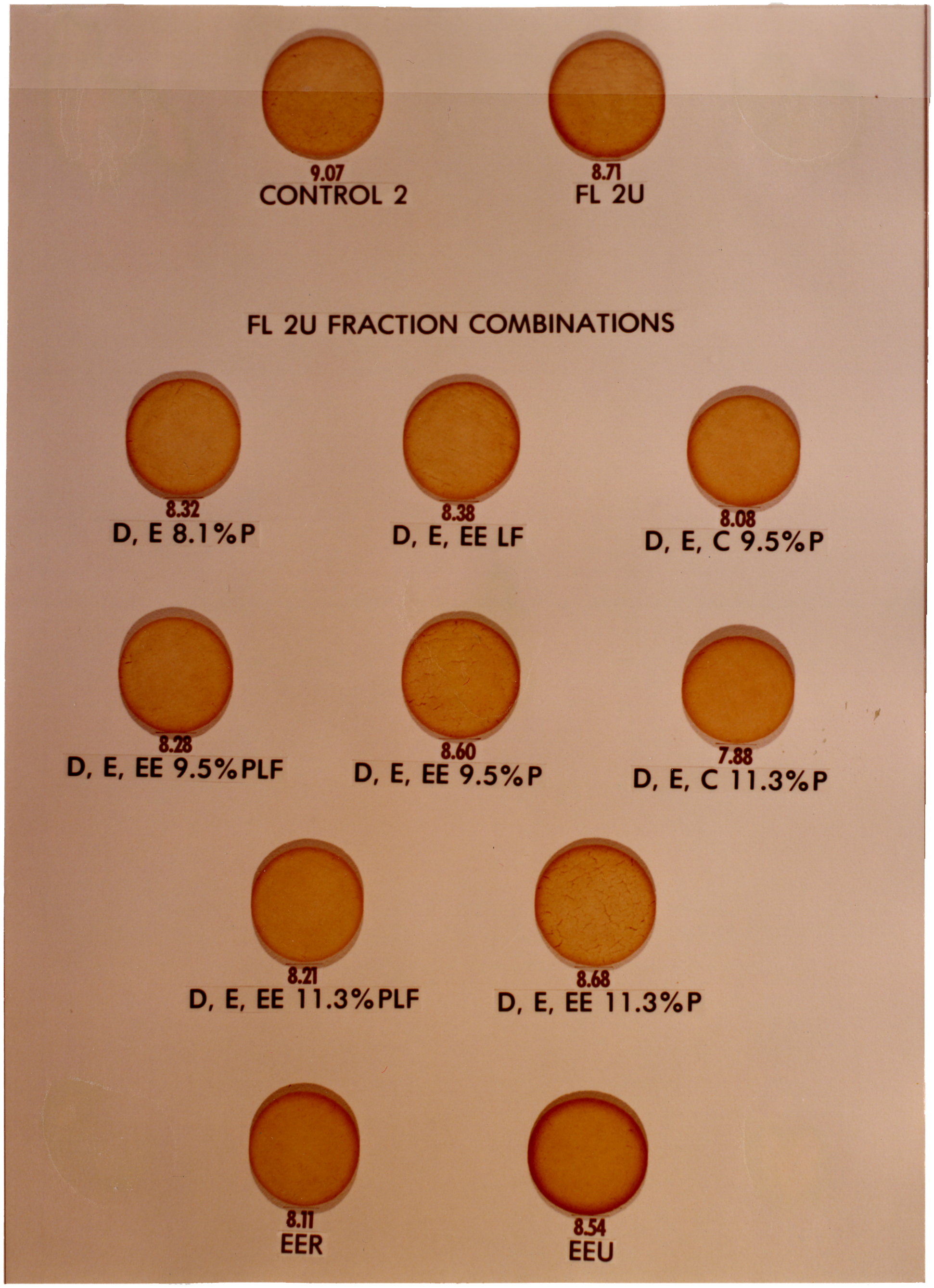


Figure 33 Results of Cookie Baking on Control Flour 2, Flour 2R, and Fraction Combinations of Flour 2R.

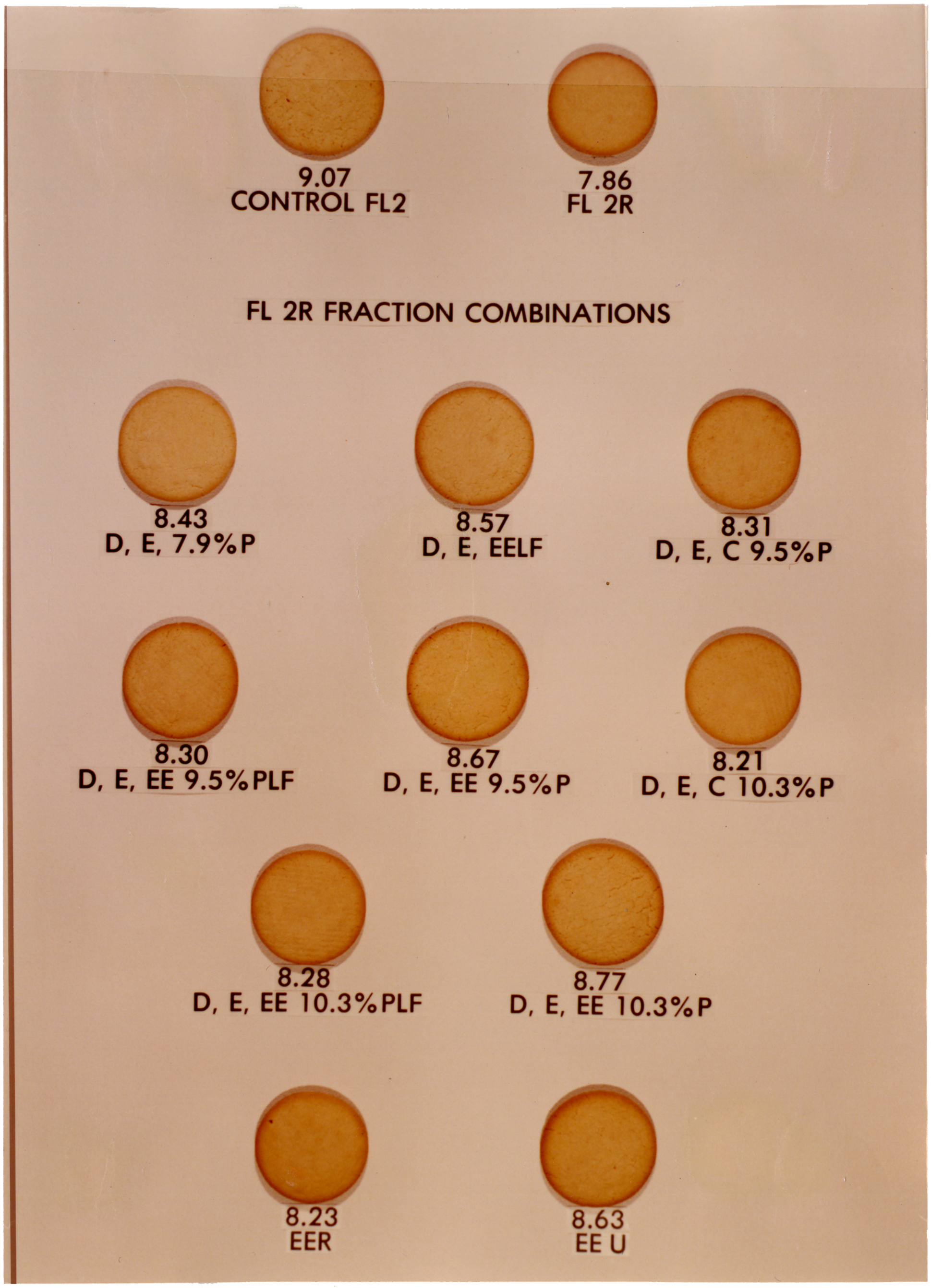


Figure 34 Results of Bread Baking on Flour IU, Flour 2U and their Fraction Combinations

CONCLUSIONS

It was shown in these experiments that flours with low particle size (fine fractions, parent or chunk fractions Reground), had poorer cookie baking quality. On the other hand the coarse fractions were shown to be more suitable for making cookies, even though they had higher protein content and particle size than that specified as normal for a good cookie flour produced from a soft wheat variety.

Suggestion for Future Work: A coarser cut should be studied in the air classifier to see if particle size could improve the cookie baking quality of a flour similar to the one used for these experiments.

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APPENDIX I

MSA WHITBY SEDIMENTATION SIZE ANALYSIS TABLES

TABLE XVIII

DIAMETER MICRONS	A	B	C	D	E	EE	CONTROL FLOUR 1
% FINER THAN							
160	99.9					99.9	99.9
120	98.0					96.0	98.25
100	91.0					92.4	94.3
80	77.9					83.4	85.9
60	58.9	99.9			99.9	58.3	68.6
40	41.4	99.7		99.9	99.6	29.2	52.45
30	31.8	99.4	99.9	99.2	79.1	14.6	44.8
20	21.1	99.0	99.4	59.3	33.9	5.4	33.9
10	4.2	97.0	51.4	7.8	0.7	1.0	6.7
5	0.1	34.0	6.0	0.9	0.0	0.0	0.1
3	0.0	6.1	0.4	0.0	0.0	0.0	0.0
2	0.0	2.4	0.0	0.0	0.0	0.0	0.0
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE XIX

DIAMETER MICRONS	A	B	C	D	E	EE	CONTROL FLOUR 1
% FINER THAN							
160						99.9	
120	99.9					99.8	
100	99.6					97.9	
80	95.9					91.4	
60	87.0				99.9	69.6	
40	68.7			99.9	99.6	35.1	
30	58.6	99.9	99.9	96.5	86.6	19.5	
20	36.1	99.5	96.2	62.2	41.7	6.4	
10	12.7	94.8	43.8	7.1	1.4	0.5	
5	3.4	39.7	8.8	0.1	0.1	0.1	
3	0.3	6.3	2.0	0.0	0.0	0.0	
2	0.0	0.8	0.1	0.0	0.0	0.0	
0	0.0	0.0	0.0	0.0	0.0	0.0	

TABLE XX

DIAMETER MICRONS	A	B	C	D	E	EE	CONTROL FLOUR 2
% FINER THAN							
160	99.9						
120	99.8					99.9	99.9
100	99.3					99.6	99.25
80	91.7					94.1	97.25
60	69.5	99.9	99.9		99.9	65.2	84.15
40	44.6	99.8	99.8	99.9	99.1	25.8	62.15
30	34.9	99.3	99.6	99.8	77.9	13.3	51.0
20	22.8	98.6	96.6	70.1	39.5	4.8	37.1
10	1.6	92.0	49.0	11.1	3.7	1.0	5.2
5	0.1	30.9	10.8	2.2	0.1	0.1	0.1
3	0.0	5.9	2.1	0.7	0.0	0.0	0.0
2	0.0	0.8	0.4	0.1	0.0	0.0	0.0
0	0.0	0.1	0.1	0.0	0.0	0.0	0.0

TABLE XXI

DIAMETER MICRONS	A	B	C	D	E	EE	CONTROL FLOUR 2
% FINER THAN							
160							
120						99.9	
100	99.9					99.5	
80	98.9					95.5	
60	89.4				99.9	76.7	
40	66.2	99.9	99.9	99.9	99.8	36.0	
30	55.7	99.7	99.8	96.4	85.4	18.4	
20	37.4	99.0	99.0	64.8	42.8	7.0	
10	9.3	91.5	57.2	10.4	1.6	0.6	
5	1.4	33.2	14.0	1.8	0.2	0.1	
3	0.3	6.9	2.9	0.5	0.1	0.0	
2	0.1	1.4	0.1	0.1	0.0	0.0	
0	0.0	0.1	0.0	0.0	0.0	0.0	

AIR CLASSIFICATION OF A COMMERCIAL HARD WHEAT FLOUR FROM MEXICO FOR COOKIE MANUFACTURE

by

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B.S., Universidad de Sonora
Mexico, 1971

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of

the requirements for the degree

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Manhattan, Kansas

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The objective of this study was to obtain a good flour for cookie manufacture. The four flour samples used for the protein control procedure were from the first and second flour of a commercial mill from Mexico, which were produced from a blend of hard and soft wheats. Both flours were air-classified as the unground and a reground flour, produced by passing the unground flour through a laboratory size Alpine Pin Mill. In the four-stage fractionation using an air classifier, two fine high protein fractions, two low protein fractions and one coarse fraction were separated. After passing through the pin mill (both flours unground), the Fisher Sub Sieve Size was reduced from 19.0 to 11.5 and from 15.50 to 13.5 for flour #1 and flour #2, respectively. After passing through an air classifier, the 9.6% protein flour #1 unground had a protein range of 6.0% - 21.7%; flour #1 reground had a protein range of 5.60% - 22.90%; 11.3% protein flour #2 unground had a protein range of 8.0% - 19.6%, and flour #2 reground had a protein range of 7.7% - 23.6%.

It was found that there was a better correlation between protein and viscosity than between protein and particle size, while protein and particle size showed better correlation than viscosity and ash, except for flour #1 unground.

Fine fractions low in protein content were blended to make a cookie flour. Later they were blended with coarse fraction EE unground, EE reground, and fine fraction C high in protein to observe the effect of protein content and particle size on flour for cookie manufacture. None of the blends with low particle size provided a good cookie flour, nor the parent and coarse fractions after regrinding, irrespective of the baking industry 'rule of thumb' that these lower protein flours should be satisfactory for cookie manufacture.

Fine fractions high in protein content were blended with coarse fractions in order to make a bread flour. There was an increase in bread loaf volume when protein content was increased. A blend of 12.5% protein made of fractions of flour #2 unground showed the highest loaf volume.

Farinogram and extensogram characteristics varied according to the varietal characteristics of the flour, since they were a blend of hard and soft wheats.