PHYSICAL, CHEMICAL, PHYSICAL-CHEMICAL, MILLING AND BAKING (COOKIE) PROPERTIES OF MILL-STREAMS AND THEIR FLOURS FROM MEXICAN WHEATS THAT VARY IN HARDNESS AND OTHER QUALITY CHARACTERISTICS

by

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INTRODUCTION

Desirable cookie flours are normally milled from soft white or soft red winter wheats. Cookies, also, can be made from hard wheat flours, but the inherent properties of those flours usually are reflected in undesirable machine-made cookies. The milling operation is a continuous process, controllable and flexible within limits, but not easily amenable to instrumentation. A valuable tool for mill control is the cookie test, because it is relatively simple, rapid, and reliable. Since important milling machinery (cleaning, grinding, and sieving) processes flour particles according to size, the property of particle size is basically important to the miller. The object of this study was to evaluate the cookie quality of Mexican wheat varieties and flour streams from a Mexican commercial flour mill in terms of granulation.

LITERATURE REVIEW

Wheat and other grains are manufactured into flour and by-products by a combination of grinding and sifting processes. Wheat is the only grain which will yield a flour capable of being made into a low-density baked product which is constructed of fine uniform cells and has a soft elastic texture.

Definition of Wheat Quality

Wheat can be broadly divided into genetically hard or soft wheat. The main differences between soft and hard wheats are usually expressed in terms of milling and baking quality characteristics of the flours (13).

The basic definition of wheat quality usually varies from one class to another and is dependent on the wheat's suitability for a given product. The quality of a soft wheat is defined in terms of its suitability for soft wheat milling and for the production of cakes, cookies, and crackers. Hard wheat quality is defined in terms of specific milling and baking properties that determine the suitability of a wheat for hard wheat milling and bread production. Milling quality, or millability, refers to those wheat properties that permit the economical production of flour. Baking quality, on the other hand, is concerned with the potential of flour to contribute to the acceptability of a baked product, and is related to milling only to the extent that it affects flour marketability. Thus, quality of any kind of wheat cannot be expressed in terms of a single property, but depends on several milling, baking, processing, and physical dough characteristics, each important in the production of bread or pastry products. A flour of good quality for cookie baking should have a low protein, low absorption, and finely granulated flour obtained usually by milling soft wheats. A flour of good quality for bread-baking should have a high water absorption, a medium to medium-long mixing requirement, a small to medium oxidation requirement, satisfactory mixing tolerance, and good loaf volume potentialities (10).

Flour Protein Levels, Flour Composition and Flour Treatment

Soft wheat flour may vary in protein from 7 to 9% in cookie flour to 10% or more in cracker and doughnut flours. Soft wheat flours may range from a 50% extra-short patent cake flour to intermediate and long patents to straights, stuffed straights and a variety of clears. They may be unbleached for cookie and pastry flours, or heavily bleached with chlorine (pH 4.5 to 4.8) for cake flours which are sometimes malted (15).

Controllable Variables in Milling

Variables controlled by the miller are: conditioning, stream selection, granulation, grinding techniques, and the amounts and kinds of additives such as malt and bleaches. One of the most useful tools at the miller's disposal is the practice called stream selection whereby a given group of similar or complementing streams are combined to make a flour suitable for a specific use (15).

Stream Analysis

The miller and chemist must become familiar with the characteristics of the different flour streams by stream analysis. A typical soft wheat stream analysis may include from 16 to 28 streams depending upon the size of the mill and details of flow. There may be 4 to 6 breaks, 5 to 9 middlings, 2 to 5 sizings and quality streams and 4 to 10 low-grade and tailings streams. A combination of low-protein streams will be similar to a straight-grade cookie flour in analysis and performance. A selection and combination of the high protein (stronger) streams will give a flour suitable for cracker sponge or doughnut production. Nelson and Lowing (15) found that the low-numbered breaks, break cuts, sizings, first middlings and most of tailings streams tend to be relatively low in protein and viscosity and high in cookie spread. The remaining middlings and low-grade streams tend to have high protein and viscosity values and bake small cookies.

Definition of Particle Size

Since the majority of powdered and granular materials used in industry include particles that deviate from sphericity, a working definition for size is needed. The size of a particle is that dimension which best describes its degree of subdivision. For a spherically symmetrical particle, the diameter is that dimension, and therefore is its size. A diameter of a particle deviating from spherical symmetry may be defined as any one dimensional distance between two points on the external surface of the particle which passes through the geometric center of the particle. For an irregular particle, a large number of non-equivalent diameters satisfying such a definition is possible, their average being the size of the particle (11).

Particle Size in Flour

An investigation of flour granulation made by Shellenberger (18) showed that wheat endosperm particles passing through a flour cloth during sieving do not always approximate the size of the aperture openings of that cloth. Wheat endosperm particles vary in size from 150 μ to approximately 5 μ in diameter. Using sieves, Wichser and Shellenberger (23) found that a decrease in the size of the flour particles, in general, was accompanied by an increase in their protein content. The 37-44 μ fraction contained the largest amount of protein, and the 0-37 μ fraction contained the least percentage of protein. That last fraction contains some free starch granules that account for the low protein content. There are definite indications that cookie spread is related to the degree of starch damage. Yamazaki (24) stated that mechanical injury to the prime starch will result in small cookies. According to Brenneis (2) this damage varies as a result of differences in intensity of grinding during production of flour.

Particle Size Related to Viscosity and to Cookie Flour Quality

The most important flour properties affecting the viscosity test include ash, protein content, pH, and granulation. To some extent the viscosity test serves as an index of soft wheat flour quality. The viscosity is lowest on the 0-37 μ fraction. Flour particles larger than 37 μ in general give a higher viscosity value. The coarsest particles gives cookies that are thick and have a tight-appearing top grain and small diameter. As the particle size decreases, the general appearance of the cookie improves slightly. Indexes of good cookie flour quality are: large diameter, well broken top grain and the thinness of cookies. The 0-37μ fraction gives a cookie that has largest diameter and excellent top grain (23).

Shortening, Sugar and Ammonium Bicarbonate Related to Cookie Quality

Finney, Yamazaki, and Morris (8) found that shortening did not affect cookie diameter but did alter top grain. Spreading of cookies during baking was directly proportional to the quantity of sugar added within each ammonium bicarbonate concentration. Increases in ammonium bicarbonate also produced proportional increases in diameter within each sugar level. When the quantity of sugar used was less than 55%, however, inferior top grain was obtained. An addition of .5% ammonium bicarbonate, in general, produced as much increase in cookie diameter and change in top grain as an increase of 7.6% sugar. A new cookie baking method, including relatively small quantities of sugar, shortening, and ammonium bicarbonate, was developed and was found to be satisfactory for evaluating cookie flour quality.

MATERIALS AND METHODS

Eight Mexican wheats varieties, one blend were subjected to moisture, protein, ash, test weight, pearling value, tempering and experimental milling. These eight wheats were different in texture, including soft, medium and hard wheats. The blend was a mixture of 90% soft Lerma Laguna and 10% hard No. 1 wheats.

Flours obtained from the Mexican wheat varieties, 21 flour streams, plus patent and clear flours from a commercial Mexican flour mill and 26 flour streams, plus patent from a commercial U. S. flour mill were subjected to moisture, protein, ash, Agtron color, Fisher sub-sieve sizer, MSA Whitby sedimentation, Alpine and ball mills, viscosity, alkaline water retention capacity (A.W.R.C.) and baking tests.

A soft wheat flour (good cookie standard) obtained from the Federal Soft Wheat Quality Laboratory, at Wooster, Ohio, and a hard wheat flour (RBS-71, poor cookie standard) obtained from the Hard Winter Wheat Quality Laboratory, at Manhattan, Kansas, were used as standards. RBS-71 (Regional Baking Standard) was a blend of many hard winter wheat varieties harvested at many stations in the Southern, Central, and Northern Great Plains in 1970.

Moisture

A.A.C.C. Cereal Laboratory Methods (5) was used for moisture determination. Evaporation of water is the principle involved. The loss in weight of any sample weight is calculated as percent moisture.

Protein

A.A.C.C. Cereal Laboratory Methods (5) was used for protein determination of wheat and flour. The test is for nitrogen and conversion factor is applied to express total protein. The sample is digested or hydrolyzed by concentrated sulfuric acid plus potassium or sodium sulphate to form ammonium salts from the nitrogen. After cooling, the digested mixture is diluted with water and then made alkaline with concentrated sodium hydroxide to release the ammonia which is distilled into standarized acid. After titrating the excess acid, the amount of nitrogen can be calculated. The factor used for wheat and wheat flour is nitrogen x 5.7.

Ash

A.A.C.C. Cereal Laboratory Methods (5) was used for determining ash content. Ash is the non-combustible reading residue after burning all else from the sample in a muffle furnace at 425° to 600°F. The ash is mostly oxides of the metallic elements which will not burn off or decompose under the test conditions. The burning to a constant weight takes from a few hours to overnight. The sample residue is then cooled, weighed, and calculated as percent ash.

Test Weight per Bushel

Test weight is the weight to nearest tenth of a pound per Winchester Bushel. The test apparatus is designed to eliminate or reduce such variables packing, vibrating effects of falling grain, and effects of non-uniform loading of the container. The Boerner weight per bushel tester with one quart kettle is illustrated in Fig. 1.

Cleaned wheat is placed in the hopper, permitted to flow into the kettle, the excess stroked off, and the kettle and contents balanced on the special beam of the apparatus. Test weight is a function of grain density and solids volume (6).

The kilograms per hectoliter is calculated from pounds per bushel by the following formula:

$$\text{Kilograms per Hectoliter} = \frac{X \cdot 453.6}{1000} \cdot 2.8378$$

Where: X = pounds per bushel
1 pound = 453.6 grams
1 kilogram = 1000 grams
1 hectoliter = 2.8378 bushels

Test weight per bushel is important in the U. S. grading system. Higher prices are paid for wheats of high test weight because, as a general rule, test weight is indicative of potential flour-yielding capacity. However, varieties may show considerable variation in test weight, and yet not show corresponding variations in flour yield (12, 20).

Pearling Value

Twenty gram wheat samples are subjected to the abrasive action of a slotted carborundum wheel for one minute at 1725 RPM in a Strong Scott laboratory barley pearler (Fig. 2) equipped with a No. 30 grit stone and 20 mesh screen made of wire 0.0413 inches in diameter (Tyler Code "Fijor"). Pearling value is percent of original sample remaining over a 20 mesh wire (26).

1000 Kernel Weight

The weight in grams of 1000 kernels of wheat was determined with an electronic seed counter (Fig. 3) using a 40 g. sample from which all foreign material and broken kernels have been removed (26).

The weight of the kernel is usually reported in 1000 kernel weight, and is indicative of the size of the kernel but does not indicate the shape. A high 1000 kernel weight is indicative of plump wheat (17).

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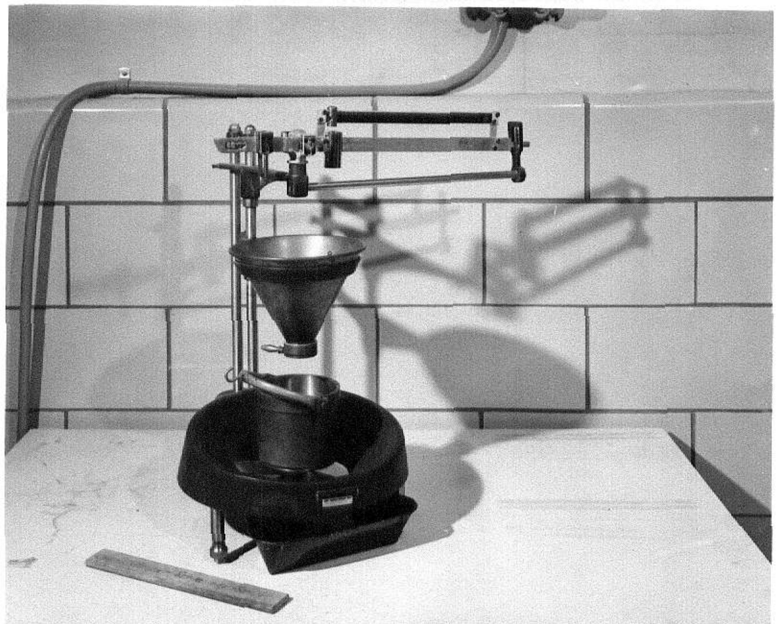

Figure 1. Boerner weight per bushel tester.

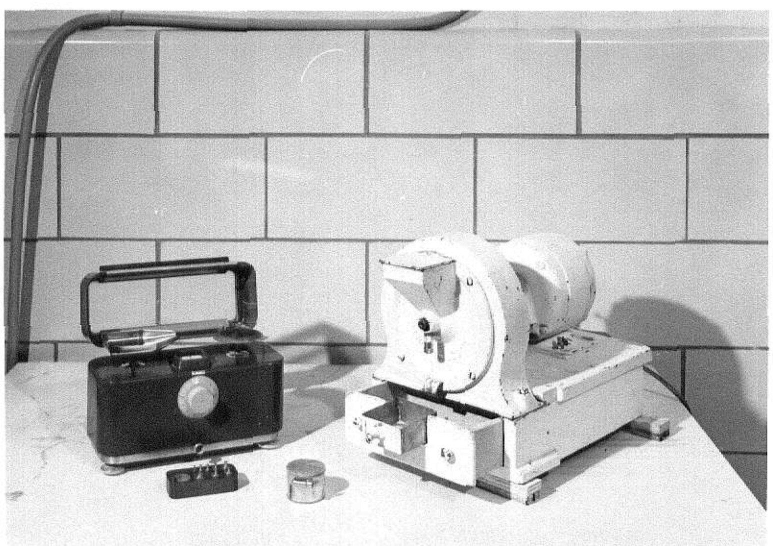

Figure 2. Strong scott laboratory barley pearler.

Wheat Size Test

Two hundred grams of wheat are placed on the top sieve of a stack of three Tyler Standard Sieves, (numbers 7, 9, 12). The stack of sieves is placed in a Ro-Tap Sifter (Fig. 4) and sifted for 60 seconds. The percentage remaining on each sieve is then determined, multiplying by factors of 78, 73, and 67 respectively and summed to obtain a single number denoting the theoretical flour yield (26).

Tempering

Tempering was accomplished by adding enough water to the wheat in the tempering device (Fig. 5) to give the wheat 15% moisture for soft wheats and 15.5% moisture for hard wheats. The wheats were held in steel cans for 20 hours before milling.

Experimental Milling

Milling of wheats was performed on the Brabender Quadrumat Senior experimental mill (Fig. 6) which consists of 3 break rolls and 3 reduction rolls, flow sheet of the experimental mill is shown in Fig. 7. Break and reduction flour were obtained and blended to obtain a straight-grade flour.

Alpine and Ball Mills

Particle size of patent flour (RH1) from the Mexican mill was further reduced on a Alpine pin mill (Fig. 8) and a ball mill (Fig. 9). The Alpine pin mill was operated at 7300, 9200, 11200, and 14000 RPM. The ball mill was operated for 6- and 24-hour periods.

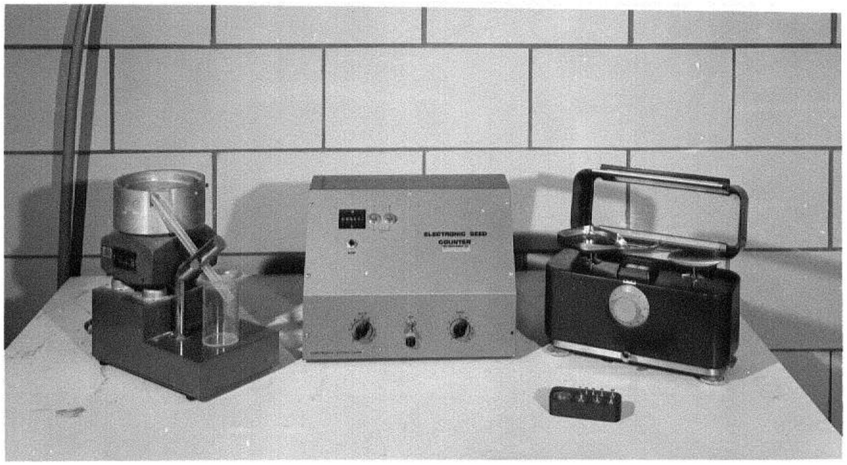

Figure 3. Electronic seed counter.

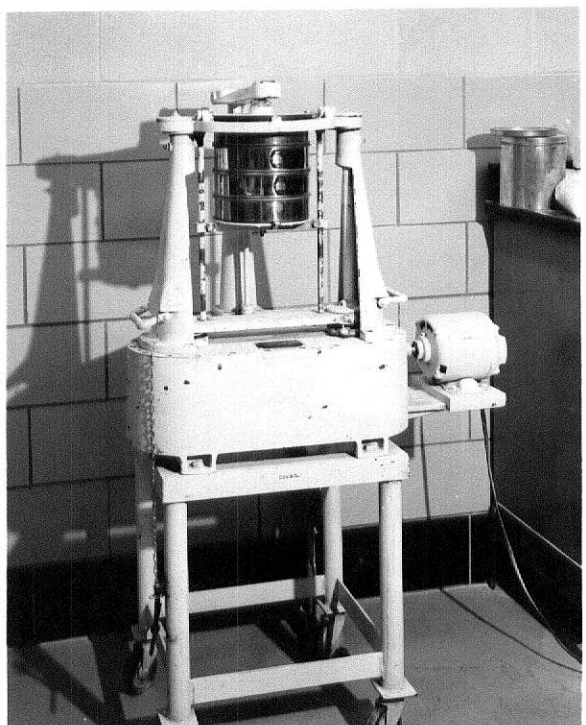

Figure 4. Ro-tap sifter.

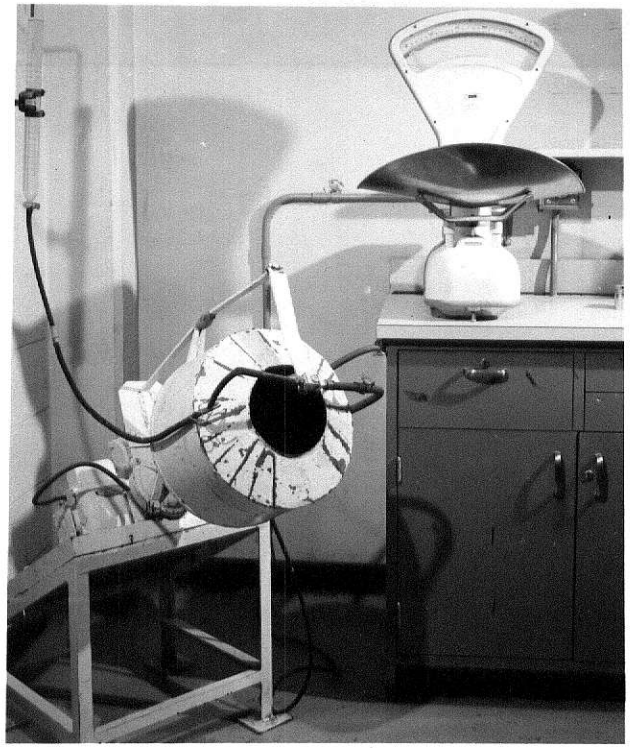

Figure 5. Tempering device.

Figure 6. Brabender quadrumat senior.

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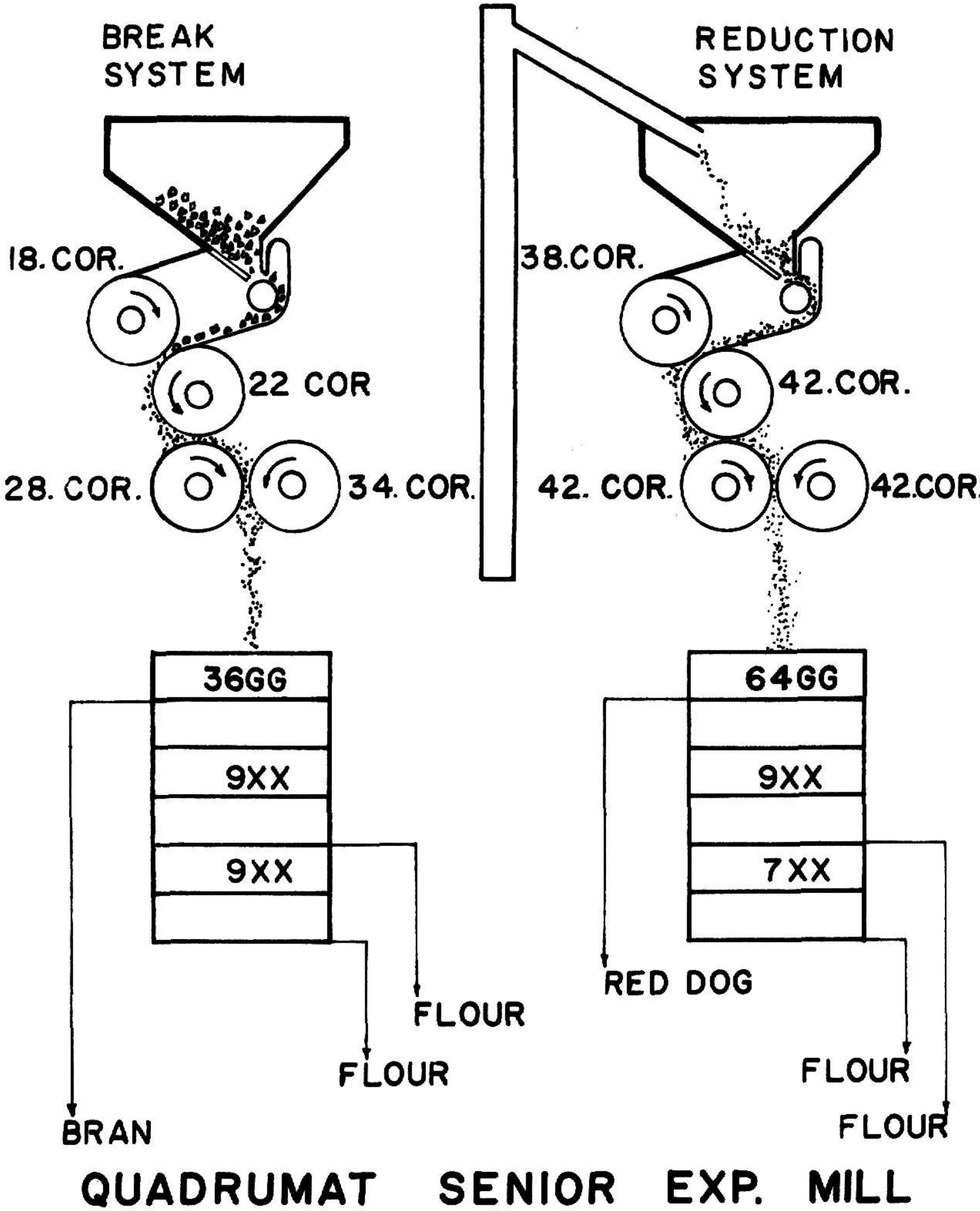


Figure 7. Flow sheet of the Brabender quadrumat senior.

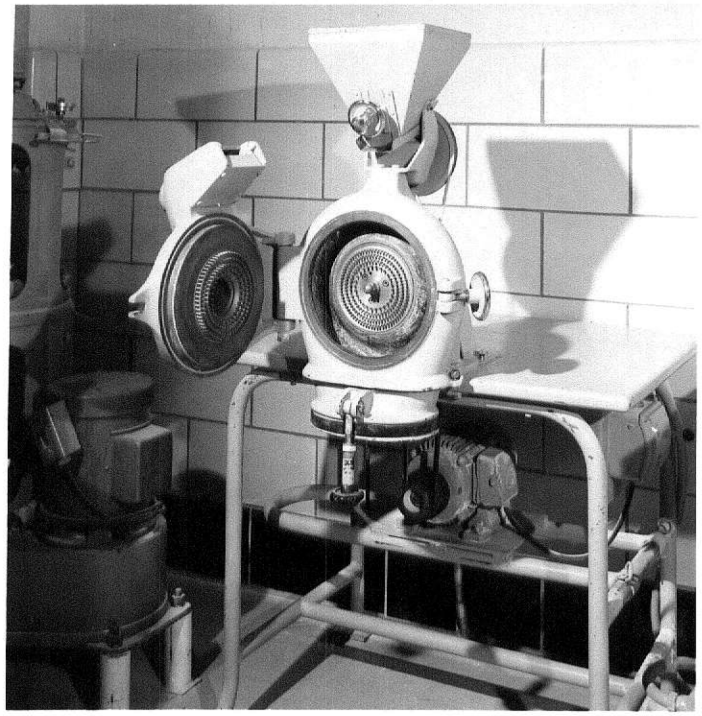


Figure 8. Alpine pin mill.

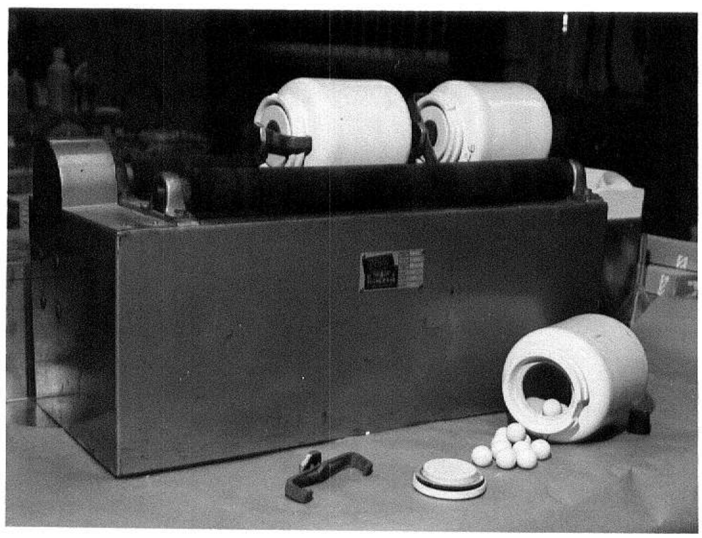


Figure 9. Ball mill.

Agtron Color

Agtron model M-500 (Fig. 10, right) was used for flour color determination. This instrument is a direct-reading reflectance spectrophotometer designed to measure the relative spectral qualities of product samples. The instrument has 4 monochromatic spectral lines: Blue-436 mμ (Hg.), Green-546 mμ (Hg.), Red 640 mμ (Ne.) and Yellow 585 mμ. Model F-2 (Fig. 11) has only 1 monochromatic spectral line: Green 546 mμ (Hg.). Flour color evaluation was performed with the Green 546 mμ wavelength light. Standard color discs 63 and 85 were used. 20 g. of flour and 25 ml. of distilled water are placed into a scrupulously clean sample cup. Using a stirring rod with pure gum rubber policeman mix flour-water mixture with a smooth circular motion for 2 minutes. Slurry is set aside in dust-free area to stand for exactly 5 minutes after mixing. Instrument is standardized with standard disc 63 adjusting meter to read 0 and with standard disc 85 adjusting meter to read 100. Place sample in sample well and record Agtron reading to the nearest unit.

Fisher Sub Sizer.

A Fisher Sub Sizer unit (Fig. 12) was employed. This commercial instrument is a self calculating device for direct determination of surface weighted mean particle diameter of powdered material. From the rate of air permeation through a compacted bed of test material, the average particle diameter can be reduced. Air flows more freely through a bed of coarse powder than through an otherwise identical bed of fine material. A system of manometer and bleed valves is used to calibrate and measure air pressure permeating the sample, with the meniscus height

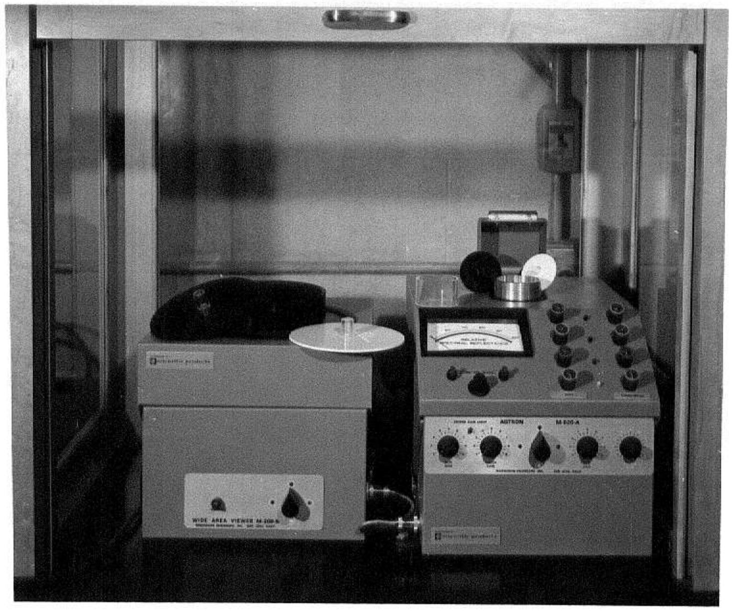


Figure 10. Agtron color meter model M-500 & M-300.

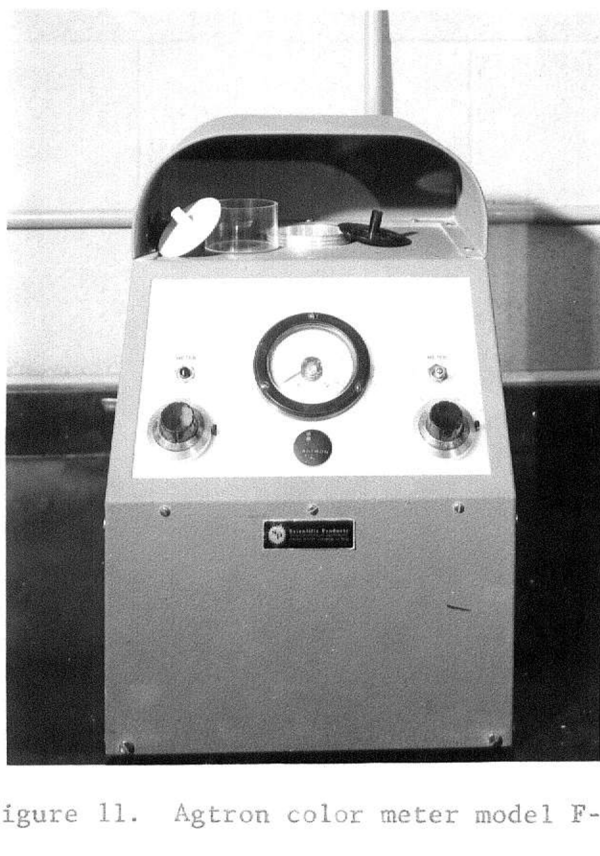


Figure 11. Agtron color meter model F-2.

as an index for mean diameter from the direct-reading chart provided. Flour samples are weighed to a value numerically equal to the material density. An average flour density of 1.44 and a porosity of 0.465 was assumed (26).

MSA Whitby Size Analysis

A.A.C.C. Cereal Laboratory Methods (5) was used for particle size determination. A Whitby sedimentation particle size analyzer (Fig. 13) was used. The sedimentation liquid used, was 4 drops of twitchell dissolved in 100 ml. of thiophene-free benzene. The feeding liquid consisted in 50% sedimentation liquid and 50% skellysolve C purified naphtha. The special centrifuge tube (1 mm. bore) is cleaned perfectly with cleaning wire. Tube is filled with sedimentation liquid to filling line, being sure that there are no bubbles in capillary. Feeding chamber is filled with feeding solution and powder scoop is used to transfer flour to feeding chamber. An appropriate reading schedule has to be selected. The values recorded are the particle size at 50% finer than and the percent of flour between 17 and 35 microns. The particle flour distribution has been plotted on semi log paper (26).

Viscosity

A.A.C.C. Cereal Laboratory Methods (5) was used for viscosity determination. A MacMichael viscosimeter (Fig. 14) with No. 30 wire was used. 20 g. flour weighed on 14% moisture basis and 100 ml. water are placed in a E-flask and shaked vigorously for 1 minute. The digestion period was omited. First reading is taken immediately dampening swing. Second reading is taken after adding 1 ml. 1N lactic acid, and third and

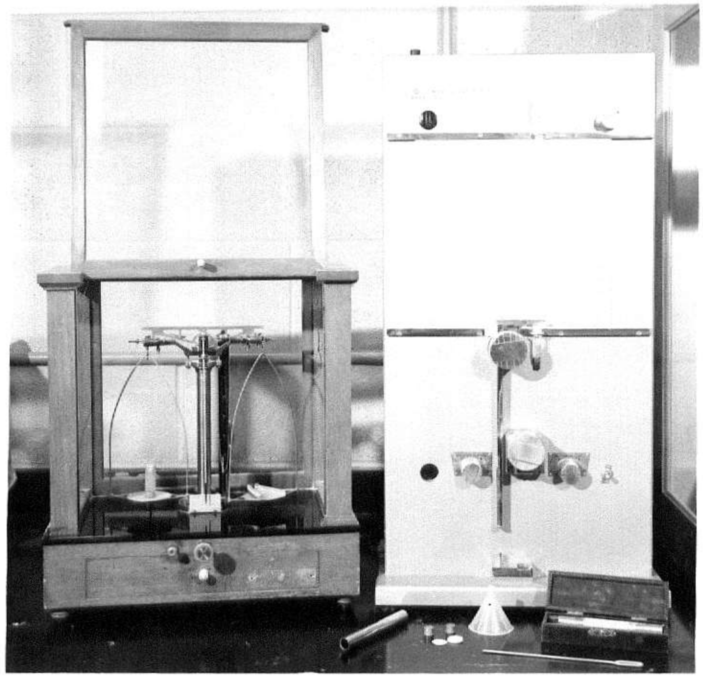


Figure 12. Fisher sub sizer.

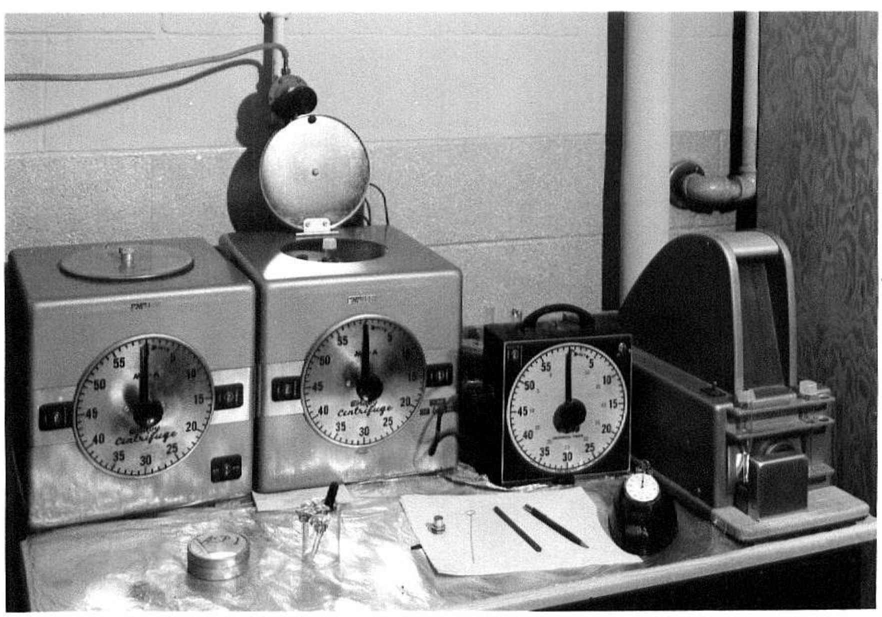


Figure 13. MSA Whitby sedimentation particle size analyzer.

subsequent readings after 2 ml. increments of the same acid. The final or maximum viscosity reading gives a measure of the protein content of the flour. That is the point at which the protein swell.

Alkaline Water Retention Capacity (A.W.R.C.)

In this test flour is hydrated in an alkaline solution. 15 g. flour (14% moisture basis) are placed into a weighed 100 ml. centrifuge tube with stopper. Add 50 ml. 0.1N sodium bicarbonate solution and shake vigorously to suspend flour. Add 25 ml. more of the same solution, shake tube and allow to stand for 20 minutes, shaking every 5 minutes. Centrifuge for 15 minutes at 1800 RPM (Fig. 15) decant off supernatant liquid and drain tube for 10 minutes at an angle of 10° to 15°. The gain in weight is expressed in percent. Higher results indicate smaller cookie diameter. This method was described by Yamazaki (25).

Baking Test

Cookies were baked following the method described by Finney, Morris, and Yamazaki (9). A Hobart mixer (Model N-50 equipped with a cake paddle and a 5-quart bowl, Fig. 16) was used for preparing in one operation all of the first stage of creamed material required for one day of baking. The remaining creaming and mixing was carried out in a National-Swanson-Working non-recording micromixer (Fig. 18) modified to give a head speed of 175 RPM, and to use a flanged and deeper bowl with a capacity of 25 g. to 50 g. of flour. The cookie cutter was made from stainless steel tubing having an inside diameter of 2 13/32 inches, thickness of 3/64 inch (18 gauge), $1\frac{1}{2}$ inches in height and was tapered from the outside inward on one end to give a sharp and rigid cutting edge. The trays were sheet aluminum 13

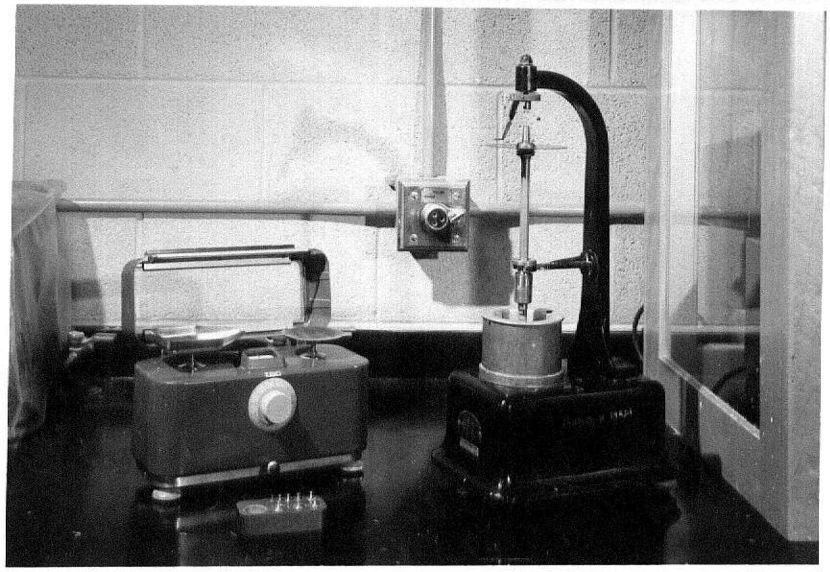


Figure 14. MacMichael viscosimeter.

Figure 15. Centrifuge for A.W.R.C.

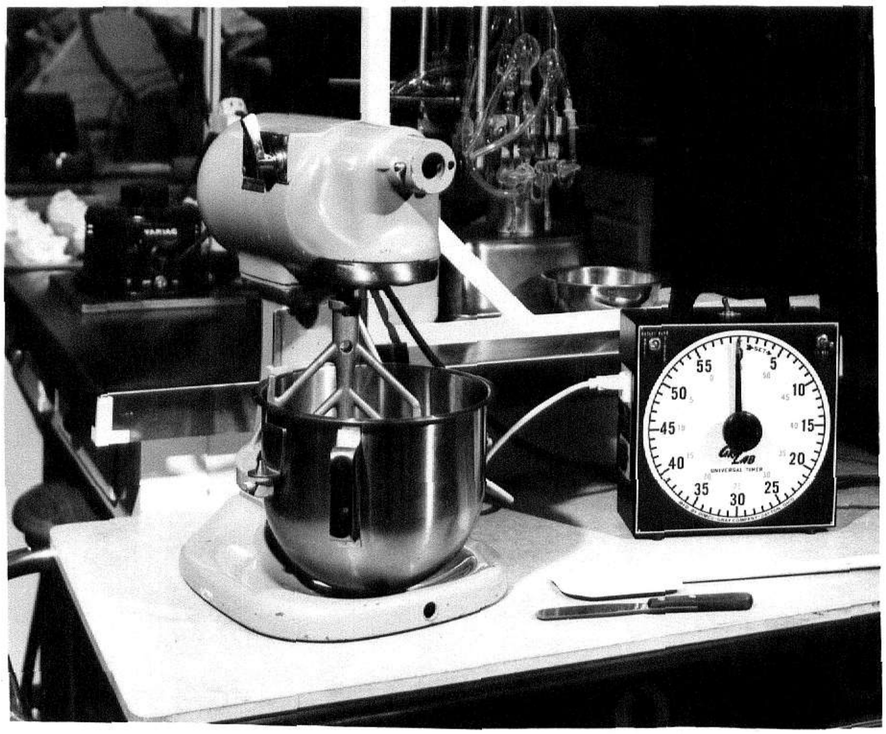


Figure 16. Hobart mixer model N-50 used for creaming.

inches x .094 inch thick with riders .275 inch high and .5 inches wide running lengthwise along both sides and attached with brass screws which were countersunk on the bottom side of the tray. The formulae and quantity of each ingredient used is given in Table. I.

Since small quantities of ammonium bicarbonate affect cookie spreading (8), and ammonium bicarbonate in the form of dry salt or in solution decomposes appreciably at room temperature, the ammonium and bicarbonate ions were added as two separate solutions. Solution A contained 159.6 g. sodium bicarbonate in 2000 ml. Solution B contained 135.53 g. ammonium chloride and 118.47 g. sodium chloride in 2000 ml. Four ml. solution A plus 3 ml. solution B furnished .3 g. ammonium bicarbonate and .4 g. sodium chloride.

Sugar 900 g., sodium bicarbonate 15 g. and nonfat milk solids 45 g. were mixed and sifted 8 times, then shortening 450 g. added and creamed together in the Hobart mixer for 30 seconds at low speed, 60 seconds at medium speed and 4 minutes at high speed, scraping down at each 15 seconds interval. This creamed mass was sufficient for 37 weighings of 37.6 g. each on small 4 x 4 inches aluminum squares (Fig. 17). Table II shows weights for sugar, sodium bicarbonate, nonfat milk solids, and shortening for varying numbers of individual creamed masses in case that only a part of the batch is needed.

One 37.6 g. portion of the creamed mass of sugar, shortening and sodium bicarbonate was transferred by means of a spatula to the micromixer bowl and creamed with 4 ml. solution A, 3 ml. solution B, and .8 to 2.3 ml. water during 3 minutes at 175 RPM. Solutions A and B were dispensed from automatic pipettes and the water from a burette (Fig. 18). Table III

Table I. Formulae for the Micro Cookie Baking Procedure.

Ingredient	Weight	Flour Basis
	g.	%
Sugar	24.00	60.00
Shortening	12.00	30.00
$NaHCO_3$	0.40	1.00
NH_4HCO_3	0.30	0.75
Nonfat milk solids	1.20	3.00
NaCl	0.40	1.00
Water	optimum	optimum
Flour	40.00	100.00

Table II. Weights of Sugar, Sodium Bicarbonate, Nonfat Milk Solids, and Shortening for Varying Number of Individual Creamed Masses.

Part of Basic Creamed Mass	Ingredient				Individual Creamed Masses
	Sugar	$NaHCO_3$	NFMS	Shortening	
%	g.	g.	g.	g.	Number
100	900	15.0	45	450	37
95	855	14.25	42.75	427.5	35
90	810	13.5	40.5	405	33
85	765	12.75	38.25	382.5	31
80	720	12.0	36.0	360	29
75	675	11.25	33.75	337.5	27
70	630	10.5	31.5	315	25
65	585	9.75	29.25	292.5	23
60	540	9.0	27.0	270	22
55	495	8.25	24.75	247.5	20
50	450	7.5	22.5	225	18

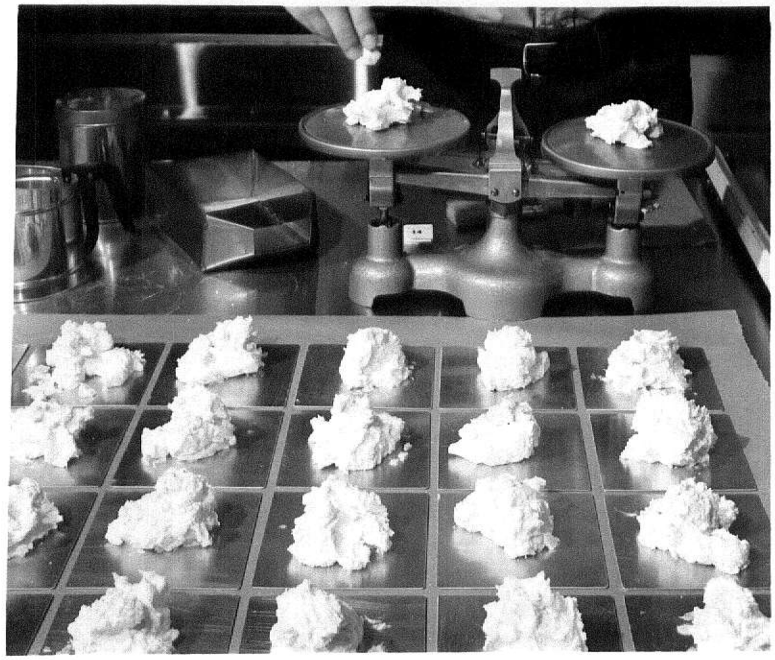


Figure 17. Dividing the cookie dough into 2 approximately equal parts.

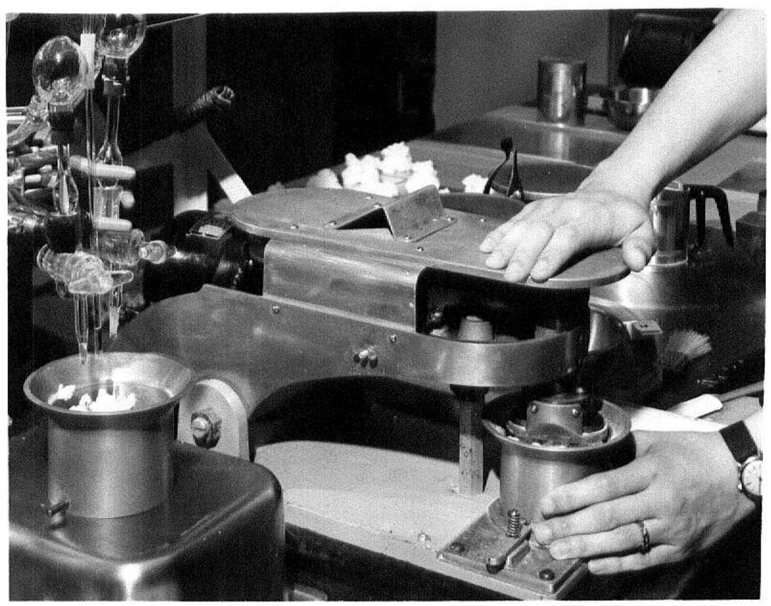


Figure 18. Automatic pipettes and micromixer.

Table III. Additional Water for Optimum Dough Consistency.

Cookie Flour Protein Range	Total[1] Absorption	Working Absorption
%	ml.	ml.
4.4 - 5.1	8.0	1.0
5.2 - 5.9	8.1	1.1
6.0 - 6.6	8.2	1.2
6.7 - 7.3	8.3	1.3
7.4 - 8.1	8.4	1.4
8.2 - 8.8	8.5	1.5
8.9 - 9.6	8.6	1.6
9.7 - 10.3	8.7	1.7
10.4 - 11.0	8.8	1.8
11.1 - 11.8	8.9	1.9
11.9 - 12.5	9.0	2.0
12.6 - 13.2	9.1	2.1
13.3 - 14.0	9.2	2.2
14.1 - 14.8	9.3	2.3
14.9 - 15.5	9.4	2.4

1/ Contains 7.0 ml. of leavening solutions.

shows additional water for optimum consistency, for first approximation. Weigh 40 g. flour (14% moisture basis), add sifted flour to creamed mass and liquids, tap bowl a few times to settle flour. Mix for 10, 5, 5, and 5 seconds the dough was dislodged with squared-off spatula from the bottom and sides of the bowl after each interval. After mixing, the dough was removed from the bowl and divided into two approximately equal parts (Fig. 17) with the aid of a spatula, care being taken to handle and compress the dough as little as possible. After spacing on a tray (Fig. 19A) the two doughs were rolled once with a wooden rolling pin (Fig. 19B) and cut with a stainless steel cutter, dough outside the cutter being removed with a spatula before raising the cutter (Fig. 19C) the excess dough was used for making a third cookie as the method described above (Fig. 19D). Baking was carried out immediately for 10 minutes at 400°F. in a reel type oven (Fig. 20). Cool for 5 minutes before removing from cookie tray. Diameter was measured (Fig. 21) after the whole baking was done. Finney, Morris, and Yamazaki (9) found a large variability in thickness measurement. Since D/T values are a function of thickness as well as diameter, it is believed that a more accurate characterization of cookies is obtained by using diameter alone. Top grain was scored on the basis of 0 for a compact, hard-appearing cookie with no breaks, to 9 for a well-broken top containing numerous small "islands" characteristic of cookies baked from good quality cookie flours.

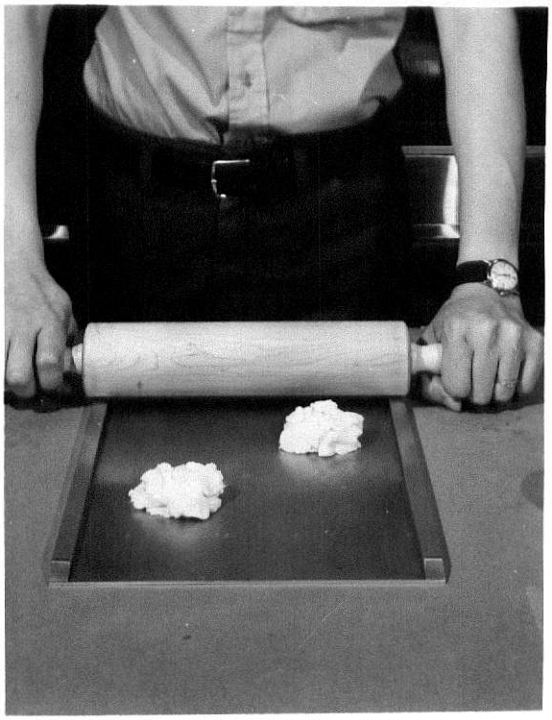


Figure 19A.

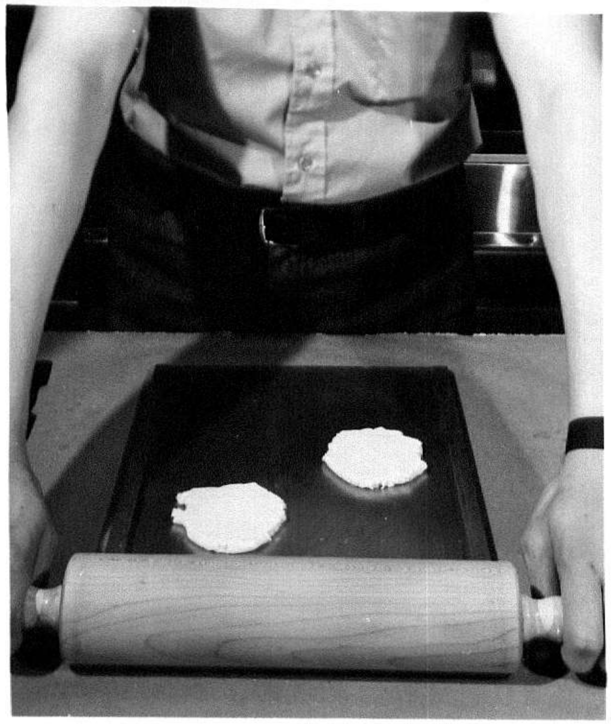


Figure 19B.

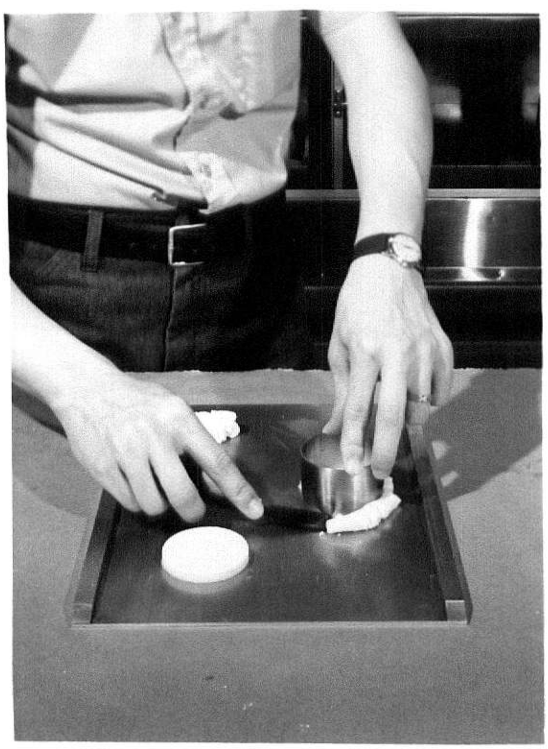


Figure 19C.

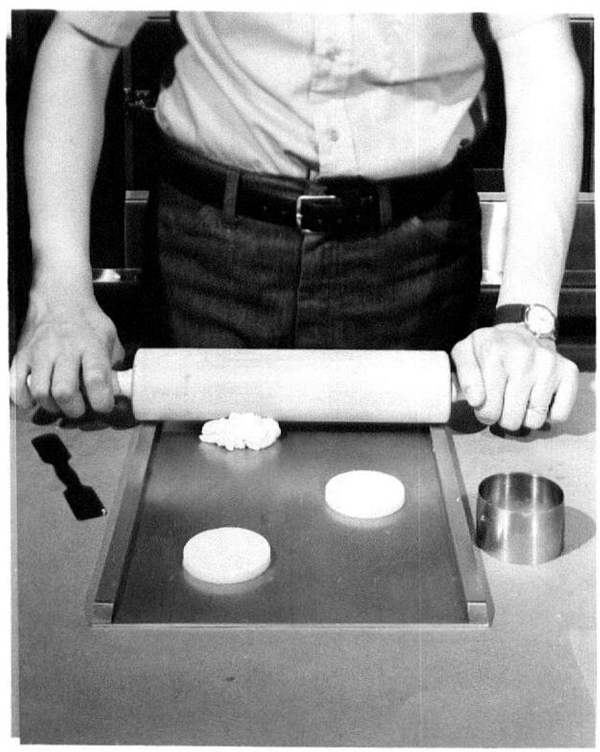


Figure 19D.

Figure 19A. Spacing dough on a tray.

Figure 19B. Rolling dough with wooden pin.

Figure 19C. Cutting dough with the stainless steel cutter.

Figure 19D. Making the third cookie.

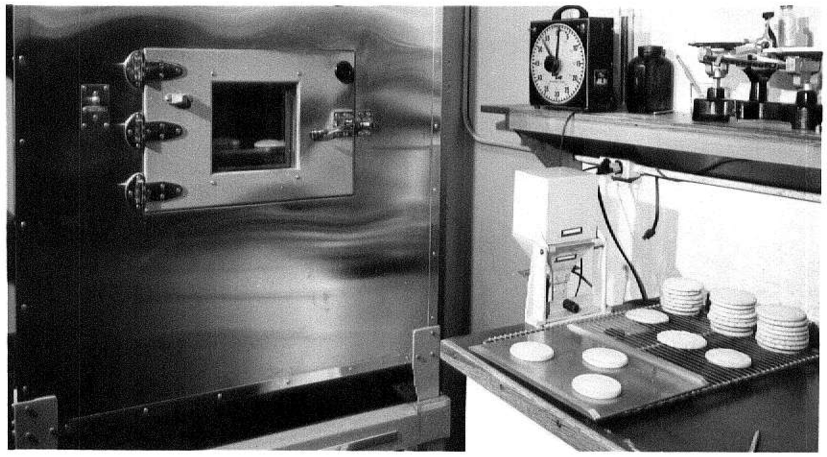


Figure 20. Reel type oven and cooling of the cookies.

Figure 21. Measuring diameter of cookies by sliding 12 in. square on a 24 in. square.

RESULTS AND DISCUSSION

Mexican Wheat Varieties

Milling properties of eight Mexican wheat varieties and one blend (90% soft Lerma Laguna and 10% hard No. 1 wheat) are presented in Table IV. Test weight per bushel is not a good index of flour yield capacity between varieties, and pearling index does not accurately predict kernel texture. Break flour yield, however, is a good index of kernel texture.

Quality characteristics of flours milled from the Mexican wheat samples and two U.S. standards are presented in Table V. Cookies are shown in Fig. 22. Although A.W.R.C. obviously is related to cookie diameter, there appears to be essentially no relationship between acid viscosity and cookie diameter.

Lerma Jimenez and Lerma Laguna wheat flours produced the best cookies. Lerma Jimenez was slightly better than Lerma Laguna. The quality obtained the blend was comparable to that obtained from the straight Lerma Laguna and Lerma Jimenez wheats. It should be pointed out that a different lot of Lerma Laguna was used in the blend. The cookie diameter of the blend (17.52 cm.) indicates that Lerma Laguna in the blend was of better quality than the other sample of Lerma Laguna (17.22 cm.). Had this particular lot of Lerma Laguna been utilized straight, most surely cookie quality would have been the highest of the group. Barrigon wheat, in spite of being soft, produced a poor cookie flour, presumably because protein quality was poor. Penjamo Region and Penjamo Chihuahua possessed good cookie quality. Why not use those two medium textured wheats in blends with Lerma Laguna and Lerma Jimenez instead of hard wheats to obtain

Table IV. Milling Characteristics of Mexican Wheat Varieties.

Variety	Texture	Test Weight Lb/Bu	Test Weight Kg/Hl	Moisture %	Ash[1/] %	Protein[1/] %	Pearling Index %	1000 Kernel Weight gms.	Theoretical Yield %	Break Flour Yield %	Flour Yield %
Lerma Laguna	Soft	60.65	78.14	9.9	1.34	11.8	49.45	35.90	77.10	25.58	67.61
Lerma Jimenez	Soft	59.70	76.92	9.7	1.33	11.0	45.40	33.36	76.97	23.16	62.62
Barrigon	Soft	57.35	73.89	9.3	1.38	9.9	47.30	38.24	77.58	23.52	66.46
Penjamo Region	Medium	61.50	79.24	9.6	1.33	10.5	76.10	33.67	77.32	21.58	66.76
Penjamo Chihuahua	Medium	61.35	79.04	9.3	1.33	11.2	65.30	36.76	77.05	21.70	67.38
7 Cerros	Hard	61.90	79.75	9.0	1.32	11.1	66.10	34.54	76.74	17.47	67.70
No. 1	Hard	60.10	77.43	10.6	1.44	12.7	64.26	38.28	77.43	19.20	67.31
Inia	Hard	62.70	80.78	9.3	1.23	12.0	85.35	36.00	77.08	19.22	66.68
Blend	90% Soft 10% Hard	62.60	80.65	10.4	1.34	11.0	62.10	35.46	77.28	20.82	68.99

1/ Values reported on a 14% moisture basis.

Table V. Quality Characteristics of Flours from Mexican Wheat Varieties and Two U.S. Standards.

Variety	Texture	Moisture %	Ash[1/] %	Protein[1/] %	Milling Ratio %	Agtron Color Green %	Ave. Particle Size: Fisher S.S.S. μ	Ave. Particle Size: MSA Whitby μ	Ave. Particle Size: Between 17-35 μ %	Acid Viscosity[1/] °MacM	A.W.R.C.[1/] %	Cookie: Diameter cm.	Cookie: Top Grain Score
Mexican													
Lerma Laguna	Soft	12.7	0.39	10.3	28.61	81.0	19.5	-	-	72.0	51.49	17.22	7.0
Lerma Jimenez	Soft	13.2	0.33	9.6	29.62	94.0	15.3	-	-	67.5	47.36	17.52	7.5
Barrigon	Soft	13.4	0.47	8.0	19.46	90.0	27.0	-	-	14.0	55.93	15.81	3.0
Penjamo Region	Medium	13.4	0.33	8.7	33.76	80.0	14.4	-	-	46.0	53.73	17.16	7.0
Penjamo Chihuahua	Medium	13.1	0.33	9.7	34.38	83.0	15.5	-	-	69.0	51.52	17.24	6.0
7 Cerros	Hard	13.9	0.38	9.6	29.70	85.5	22.0	-	-	76.0	59.22	15.84	3.0
No. 1	Hard	14.4	0.32	10.9	35.31	78.5	14.5	-	-	90.0	53.41	16.24	3.0
Inia	Hard	14.0	0.34	10.9	32.68	90.0	27.0	-	-	122.0	52.05	16.11	3.0
Blend	90% Soft 10% Hard	14.1	0.33	9.5	35.99	91.0	13.9	-	-	65.0	49.60	17.52	7.0
Standards													
Good	Soft	12.5	0.42	9.9	--	72.0	16.4	36	24	55.0	47.43	17.93	8.0
Poor	Hard	12.1	0.40	12.3	--	77.0	22.0	38	30	154.0	58.49	15.27	1.0

1/ Values reported on a 14% moisture basis.

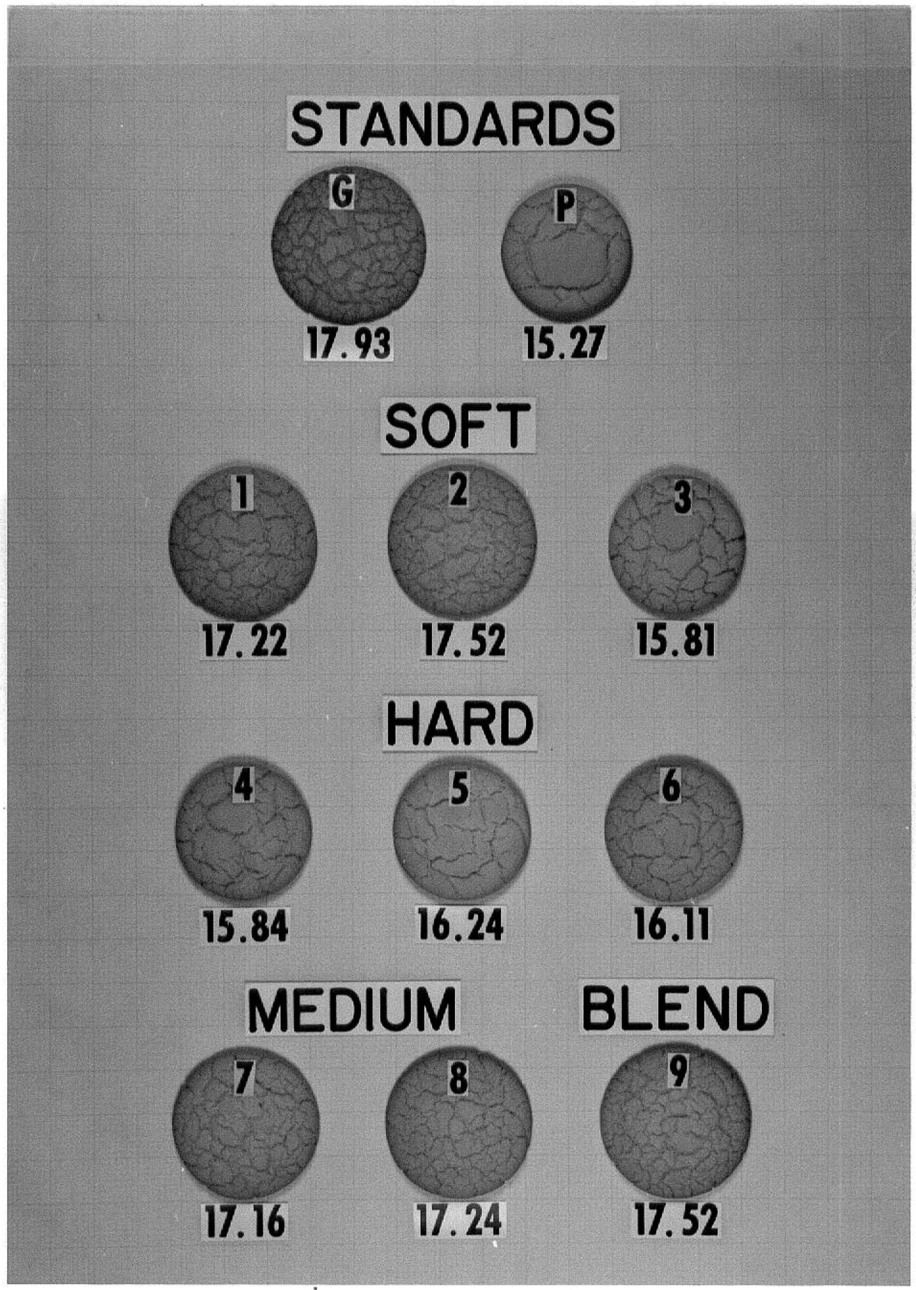


Figure 22. Baking test of flours from Mexican wheat varieties.

superior cookie quality? The hard wheats (7 Cerros, No. 1, and Inia), as expected, possessed poor cookie flour quality.

Mexican Commercial Mill Streams

Quality characteristics of flour streams from a Mexican flour mill are presented in Table VI. Table VII shows the different flour streams of the Mexican flour mill and how they were used to calculate the cumulative ash and protein (72% extraction was assumed). A cumulative curve was drawn for ash and protein in order of increasing ash (Fig. 23). Cookies baked from the flour streams are reproduced in Figs. 24A and 24B.

From Table VI and Figs. 24A and 24B, streams best suited for cookie flour can be selected. Factors affecting the selection are relatively low viscosity, low A.W.R.C., large cookie diameter, and high top grain score. Accordingly a good cookie flour can be obtained by blending the following streams:

First Break	(T1)
Second Break	(T2)
1-2 Break Grader	(RS1)
Third Break	(T3)
Sizings	(D1)
First Midds	(C1)
Second Midds	(C2)
Third Midds	(C3)
Fourth Midds	(C4)
Fifth Midds	(C5)
Sixth Midds	(C6)
Good Suction	(ASP1)

Table VII shows that a 54.02% of cookie flour was obtained from the original 72% of assumed total products. The remaining 17.98% was found not to be suitable for cookie production.

Table VI. Quality Characteristics of Commercially Milled Soft Wheat Flour from Mexican Flour Mill.

Flour or Stream Mexican	U.S.A.	Flour Cloth (xx)	Moisture %	Ash[1/] %	Protein[1/] %	Agtron Color Green %	Fisher S.S.S. μ	Acid Viscosity[1/] °MacM	A.W.R.C.[1/] %	Cookie Diameter cm.	Cookie Top Grain Score
T1	1BK	10-11	12.6	0.36	8.9	76.0	16.3	60.0	43.82	18.02	8.0
T2	2BK	10-11	12.6	0.36	9.5	75.0	14.3	67.0	48.06	17.67	8.0
RS1	1-2BK GR	11-12	12.5	0.45	10.2	60.0	18.5	78.0	51.63	17.48	8.0
T3	3BK	10	12.4	0.40	10.4	78.0	13.0	77.5	50.65	17.57	7.5
RS2	3BK GR	11-12	12.4	0.42	10.8	74.5	16.0	88.0	52.01	17.20	7.0
T4	4BK	10-11	12.4	0.46	11.0	72.0	11.8	73.5	50.23	17.43	6.0
T5	5BK	11-12	12.1	0.76	14.5	33.5	13.4	59.0	53.34	16.13	2.0
D1	SIZ	10-11	12.6	0.38	8.3	80.0	15.3	38.5	50.02	17.65	8.0
C1	1M	10-11	12.7	0.31	8.9	100.0	17.0	69.0	51.52	17.77	8.0
C2	2M	10-11	12.5	0.36	9.1	91.0	16.0	64.0	51.84	17.58	8.0
C3	3M	10-12	12.6	0.34	9.3	91.5	18.0	71.0	54.18	17.40	7.5
C4	4M	10-11	12.6	0.36	9.1	90.5	16.5	57.0	53.45	17.55	7.0
C5	5M	11-12	12.3	0.36	9.6	90.0	20.0	74.0	53.03	17.66	7.5
C6	6M	11-12	12.3	0.40	10.4	80.0	17.5	80.0	52.92	17.48	7.0
C7	7M	11-12-13	12.0	0.74	11.5	40.5	14.9	30.0	57.82	16.60	3.0
C8	8M	11-12	12.0	0.42	10.4	76.0	15.8	84.0	54.81	16.68	4.5

Table VI. (Continued), page 2.

Flour or Stream Mexican	U.S.A.	Flour Cloth	Moisture	Ash[1/]	Protein[1/]	Agtron Color Green	Fisher S.S.S.	Acid Viscosity[1/]	A.W.R.C.[1/]	Cookie Diameter	Cookie Top Grain
		(xx)	%	%	%	%	μ	°MacM	%	cm.	Score
C9	9M	11-12-13	12.0	0.49	10.9	58.0	20.0	95.0	60.48	16.32	3.0
C10	10M	9-11-12	11.8	0.68	11.5	44.5	21.0	57.0	63.14	16.06	2.0
ASP1	G SUCT[2/]	10-11	12.5	0.50	10.2	68.0	13.0	54.0	55.02	17.72	8.0
ASP2	P SUCT[3/]	12-13	12.4	0.73	13.7	26.5	12.2	62.0	55.23	16.45	3.0
RF	LG	10-11-12	12.1	0.79	11.8	40.0	18.2	38.0	64.37	16.19	3.0
RH1	PAT[4/]	5	12.4	0.53	9.2	93.0	13.7	62.0	50.19	17.68	8.0
RH2	CL[5/]	6	12.1	0.49	10.8	63.8	16.0	63.5	54.12	17.35	7.0

1/ Values reported on a 14% moisture basis.

2/ Good Suction.

3/ Poor Suction.

4/ Patent.

5/ Clear.

Table VII. Cumulative Ash and Protein for Flour Streams from Mexican Flour Mill.

	Stream Weight	Q	S of Q	A	Q X A	S of Q X A	S of Q X A / S of Q	Q X P	S of Q X P	S or Q X P / S of Q	P
Flour Stream	i.e. gram/ min.	% of Total Product	Cumulative % of Total Products	% Ash 14% M.B.	% of Total Product X % Ash	Cumu-lative Q X A	Cumu-lative % of Ash	% of Total product X % Protein	Cumu-lative Q X P	Cumulative % of Protein	Remarks 14% M.B.
C1	14.69	11.00	11.00	0.31	3.465	3.465	0.315	97.49	97.49	8.86	8.9
C3	5.32	3.99	14.99	0.34	1.372	4.387	0.322	36.91	134.40	8.96	9.3
C2	10.00	7.49	22.48	0.36	2.719	7.556	0.336	68.46	202.86	9.02	9.1
C5	6.86	5.14	27.62	0.36	1.866	9.422	0.341	49.34	252.20	9.13	9.6
T1	2.09	1.57	29.19	0.36	0.571	9.993	0.342	13.91	266.11	9.11	8.9
T2	5.03	3.77	32.96	0.36	1.372	11.365	0.344	35.63	301.74	9.15	9.5
C4	8.76	6.56	39.52	0.36	2.388	13.753	0.348	59.37	361.11	9.13	9.1
D1	4.64	3.47	42.99	0.38	1.329	15.082	0.350	28.66	389.77	9.06	8.3
T3	6.37	4.77	47.76	0.40	1.917	16.999	0.355	49.61	439.38	9.19	10.4
C6	5.18	3.88	51.64	0.40	1.560	18.559	0.359	40.31	479.69	9.28	10.4
C8	2.44	1.82	53.46	0.42	0.764	19.323	0.361	18.85	498.54	9.32	10.4
RS2	2.38	1.78	55.24	0.42	0.751	20.074	0.363	19.21	517.75	9.37	10.8
RS1	1.88	1.40	56.64	0.45	0.633	20.707	0.365	14.31	532.06	9.39	10.2

Table VII. (Continued), page 2.

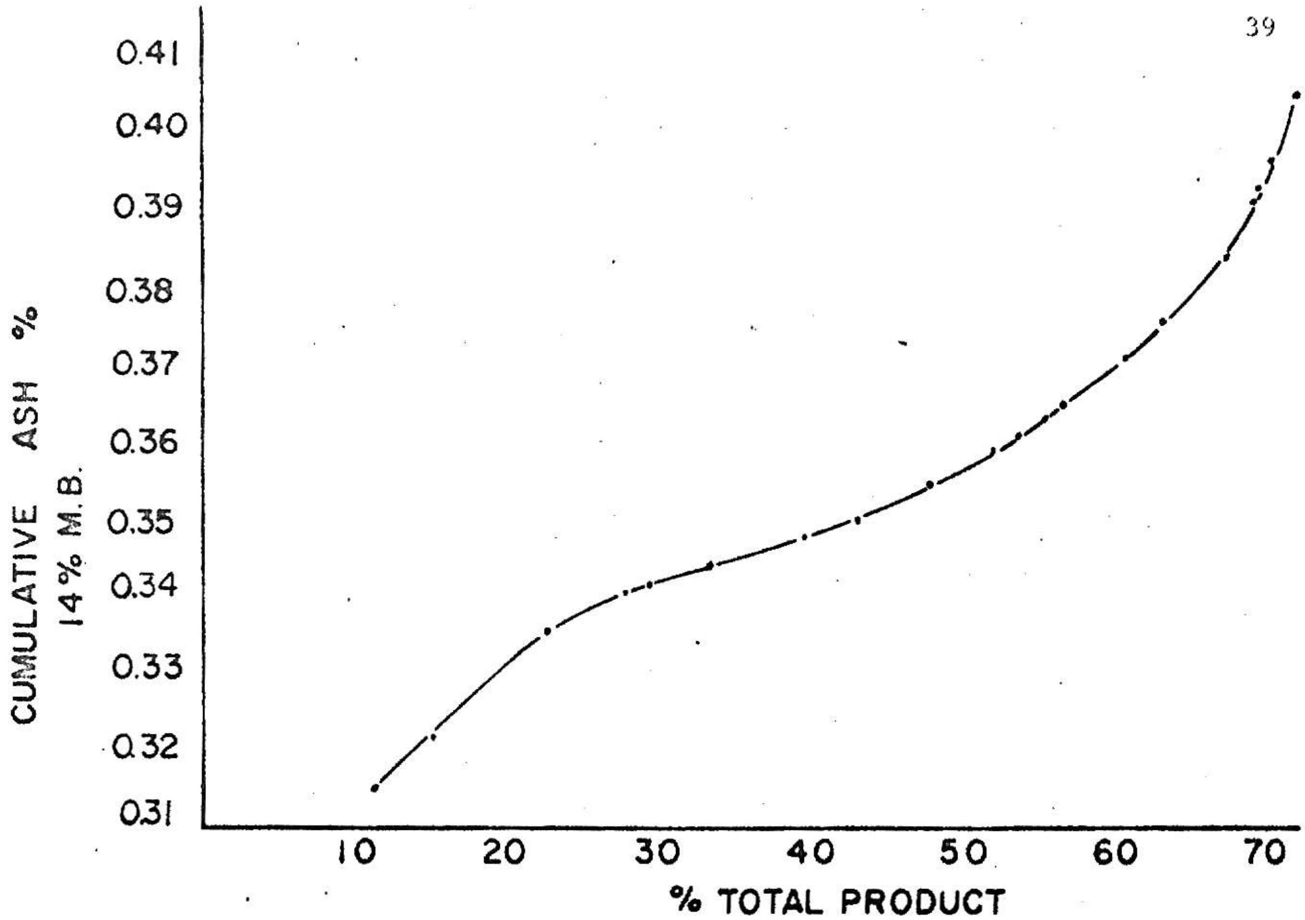
	Stream Weight	Q	S of Q	A	Q X A	S of Q X A	S of Q X A / S of Q	Q X P	S of Q X P	S of Q X P / S of Q	P
Flour Stream	i.e. gram/ min.	% of Total Product	Cumulative % of Total Products	% Ash 14% M. B.	% of Total Product X % Ash	Cumu- lative Q X A	Cumu- lative % of Ash	% of Total Product X % Protein	Cumu- lative Q X P	Cumulative % of Protein	Remarks 14% M.B.
T4	5.17	3.87	60.51	0.46	1.784	22.491	0.371	42.53	574.59	9.49	11.0
C9	3.09	2.31	62.82	0.49	1.150	23.641	0.376	25.27	599.86	9.54	10.9
ASP1	5.98	4.48	67.30	0.50	2.240	25.881	0.384	45.78	645.64	9.59	10.2
C10	2.08	1.55	68.85	0.68	1.057	26.938	0.391	17.82	663.46	9.63	11.5
ASP2	0.56	0.41	69.26	0.73	0.302	27.240	0.392	5.63	669.09	9.66	13.7
C7	1.01	0.75	70.01	0.74	0.556	27.796	0.397	8.65	677.74	9.68	11.5
T5	2.33	1.74	71.75	0.76	1.328	29.124	0.405	25.18	702.92	9.79	14.5
RF	0.23	0.17	71.92	0.79	0.135	29.259	0.406	2.01	704.93	9.80	11.8

P = Protein

A = Ash

Q = Quantity

S = Summation


CUMULATIVE ASH %
14% M.B.
0.41
0.40
0.39
0.38
0.37
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0.32
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10
20
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40
50
60
70
% TOTAL PRODUCT

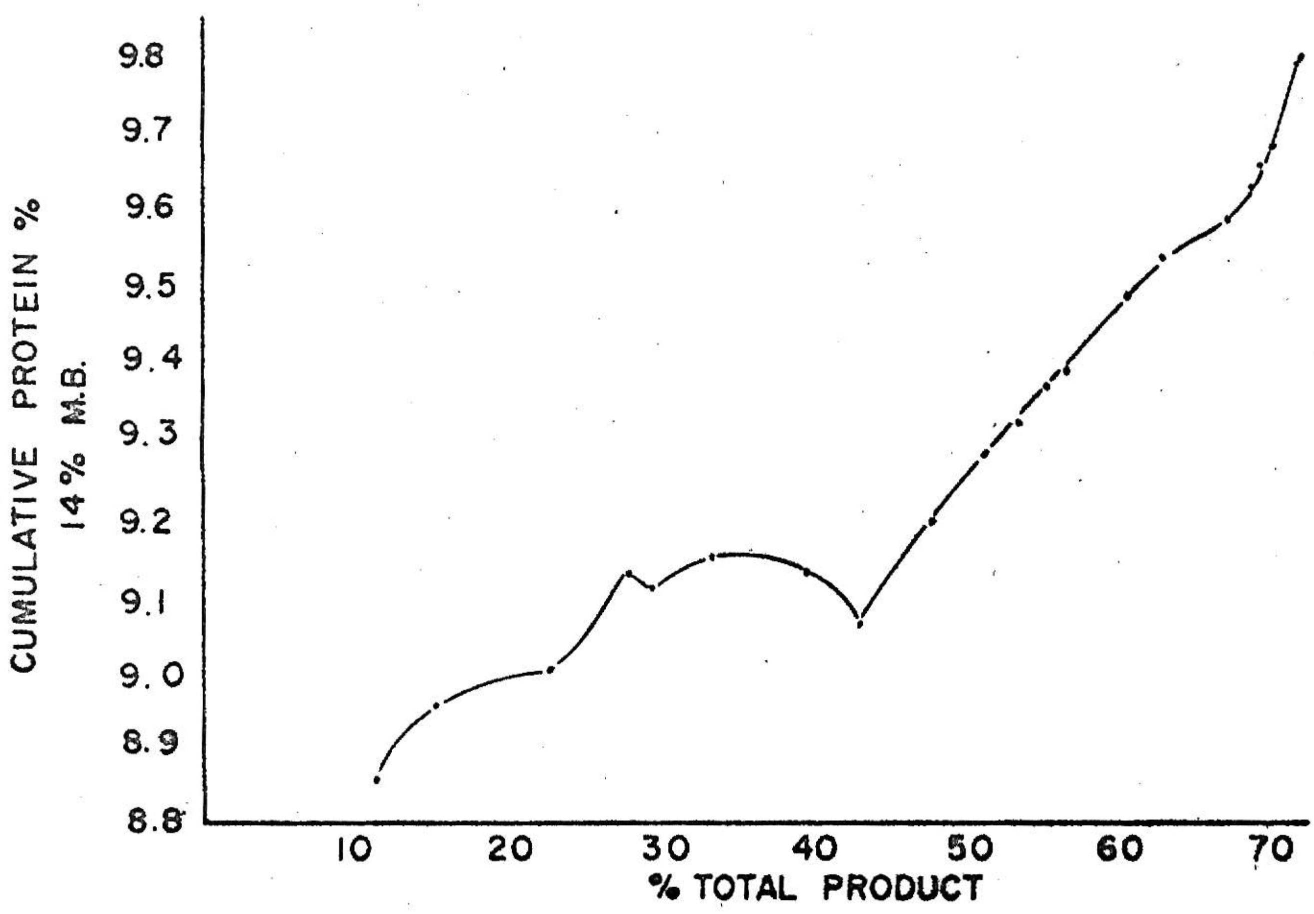
CUMULATIVE PROTEIN %
14% M.B.
9.8
9.7
9.6
9.5
9.4
9.3
9.2
9.1
9.0
8.9
8.8
10
20
30
40
50
60
70
% TOTAL PRODUCT

Figure 23. Cumulative curve for ash and protein in order of increasing ash.

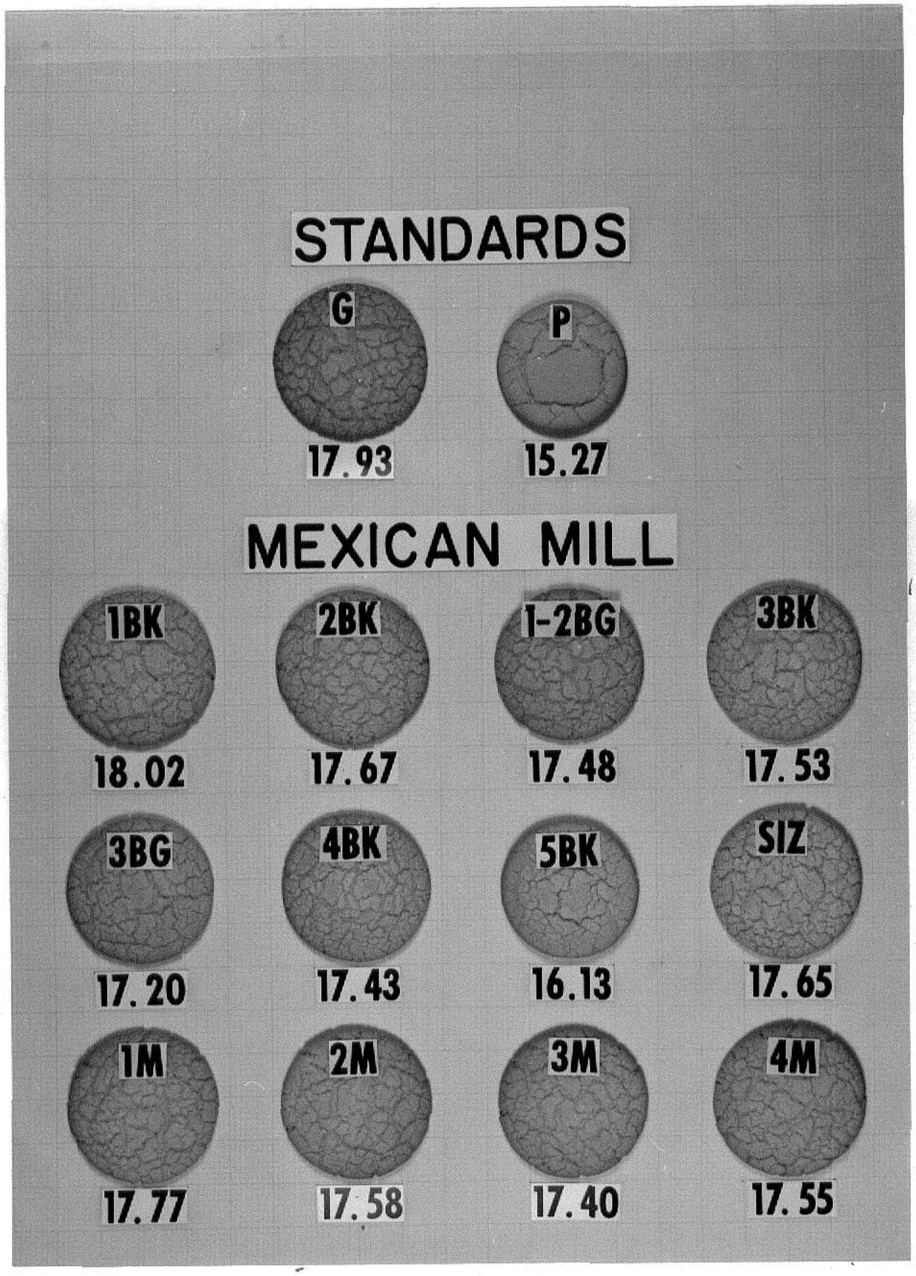

Figure 24A. Baking test of flours from a Mexican flour mill.

Figure 24B. Baking test of flours from a Mexican flour mill (continued).

U.S. Commercial Mill Streams

For comparison, quality characteristics of flour streams from a U.S. commercial flour mill are presented in Table VIII. Cookies baked from the streams are reproduced in Figs. 25A and 25B.

A good cookie flour can be obtained by blending the following U.S. streams:

First Break
1 Break Grader
Second Break
Third Break
2-3 Break Grader
Fourth Break
A Sizings
First Midds
Second Quality
First Tailings
Second Tailings
Bran and Short Duster
Midds Scalp

It should be pointed out that only first midds from the U.S. mill is a component of the cookie flour; instead, the first six midds were used in the Mexican cookie flour. It is noteworthy that the Mexican mill has ten midds, some of which probably are similar to quality and tailings streams found in the U.S. system.

Studies with Alpine Pin and Ball Mills

Data on the further reduction of Mexican patent flour (RH1) on the Alpine pin and ball mills are presented in Table IX. Fisher S.S.S. values for particle size consistently decrease and A.W.R.C. consistently increase with decreasing cookie diameter.

Table VIII. Quality Characteristics of U.S. Commercial Flour Mill.

Flour or Stream	Moisture	Ash 1/	Protein 1/	Agtron Color Green	Fisher S.S.S.	Acid Viscosity 1/	A.W.R.C. 1/	Cookie Diameter	Cookie Top Grain Score
	%	%	%	%	μ	°MacM.	%	cm.	Score
1BK	14.7	0.38	7.7	69.0	13.7	39.0	45.57	18.45	8.5
1BK GR	14.9	0.39	8.9	69.5	14.7	48.0	46.24	17.81	7.5
2BK	14.8	0.37	7.4	72.0	13.8	52.0	46.16	18.17	8.5
3BK	14.7	0.41	8.2	69.0	13.2	84.0	46.55	17.63	7.5
2-3BK GR	14.9	0.38	9.1	75.0	14.2	83.0	45.57	17.90	8.0
4BK	14.5	0.56	10.8	58.0	13.4	52.0	46.90	17.96	7.5
5BK	14.0	0.68	12.5	49.0	13.3	22.0	54.08	17.63	6.5
A SIZ	14.6	0.37	8.3	87.5	14.7	44.0	50.40	17.89	8.0
1M	14.5	0.35	8.9	87.5	14.5	59.0	48.58	17.72	8.0
2MC	14.2	0.33	9.4	94.0	15.8	91.0	50.58	17.22	7.0
2MF	14.2	0.33	9.7	92.0	16.4	93.0	45.75	17.26	6.0
3M	13.9	0.32	9.8	97.5	16.6	106.0	50.16	17.17	5.5
4M	13.7	0.33	10.8	94.0	16.6	107.0	50.37	17.05	5.0
5M	13.6	0.39	8.5	79.8	17.8	103.0	51.91	16.74	4.5
6M	13.2	0.39	9.1	79.4	18.2	118.0	52.54	16.69	4.0

Table VIII. (Continued), page 2.

Flour or Stream	Moisture	Ash 1/	Protein 1/	Agtron Color Green	Fisher S.S.S.	Acid Viscosity 1/	A.W.R.C. 1/	Cookie Diameter	Cookie Top Grain Score
	%	%	%	%	μ	°MacM.	%	cm.	
2Q	14.8	0.38	9.5	70.0	17.6	80.0	45.26	17.68	8.0
1T	14.2	0.35	9.1	90.0	14.0	59.0	49.98	17.62	7.0
2T	13.9	0.43	9.5	81.5	12.8	49.0	54.15	17.71	8.0
1LG	13.6	0.51	11.6	64.2	15.6	72.0	52.75	17.02	6.0
2LG	13.3	0.58	11.6	54.2	18.0	62.0	53.48	16.93	5.0
3LG	13.2	0.59	11.4	53.8	18.0	50.0	54.53	16.91	4.5
4LG	13.6	1.13	12.4	17.0	16.5	16.0	56.98	15.62	1.5
P SUCT 2/	13.5	0.38	12.1	24.0	11.7	42.0	55.30	16.86	5.0
G FL 3/	13.4	0.69	12.1	48.5	14.0	40.0	51.07	17.40	6.5
B & SD 4/	13.7	0.77	11.0	41.5	12.3	31.0	54.15	17.90	7.5
M SP 5/	14.2	0.34	9.8	93.0	14.7	53.0	52.54	17.73	7.5
Pat 6/	12.4	0.46	9.5	63.0	13.6	34.0	52.92	17.78	8.0

1/ Values reported on a 14% moisture basis. 2/ Poor Suction. 3/ Germ flour.

4/ Bran and Short duster. 5/ Midds scalp. 6/ Patent.

THIS BOOK WAS BOUND WITH TWO PAGES NUMBERED 45. THESE PAGES ARE DIFFERENT.

THIS IS AS RECEIVED FROM CUSTOMER.

Figure 25A. Baking test of flours from a U.S. commercial flour mill.

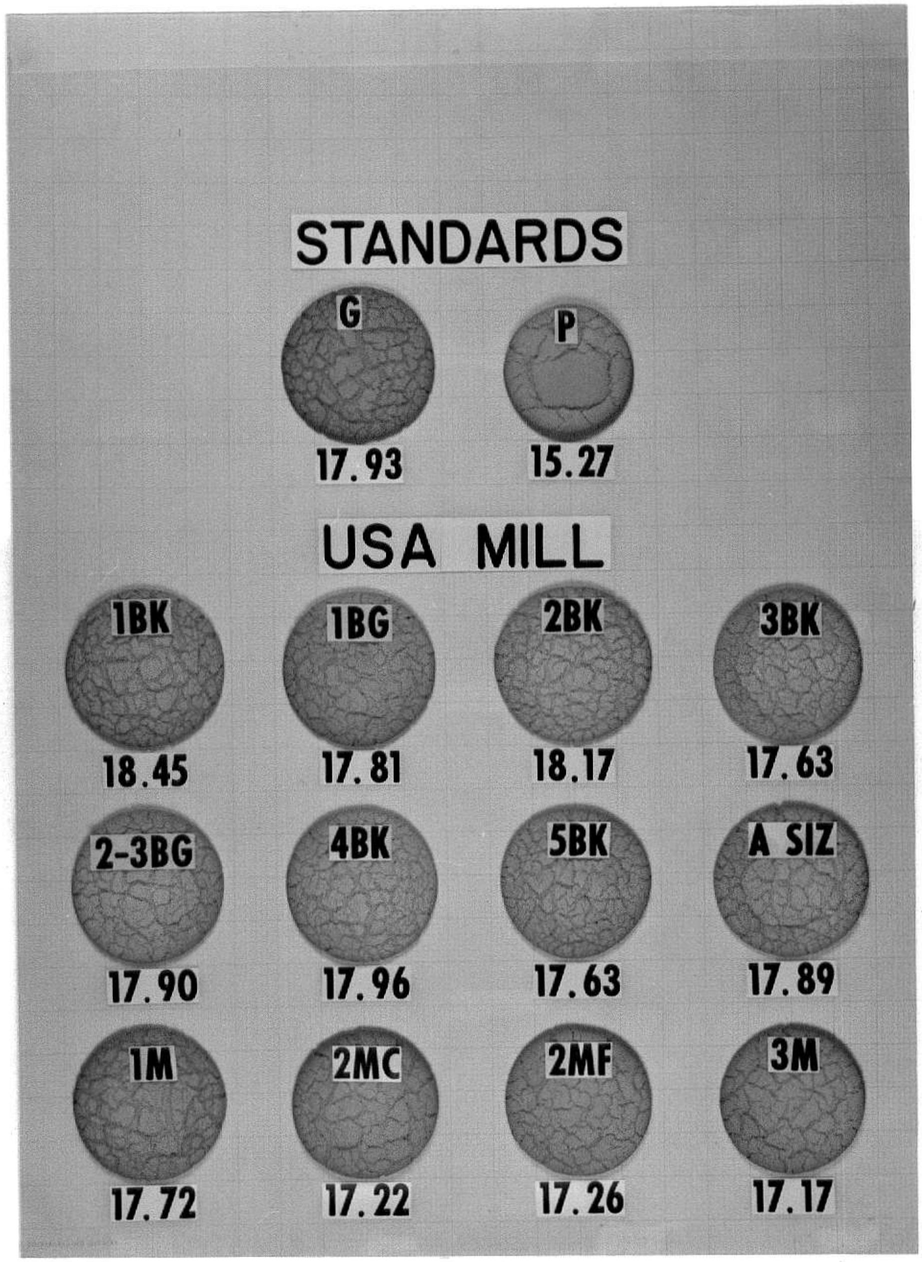

Figure 25A. Baking test of flours from a U.S. commercial flour mill.

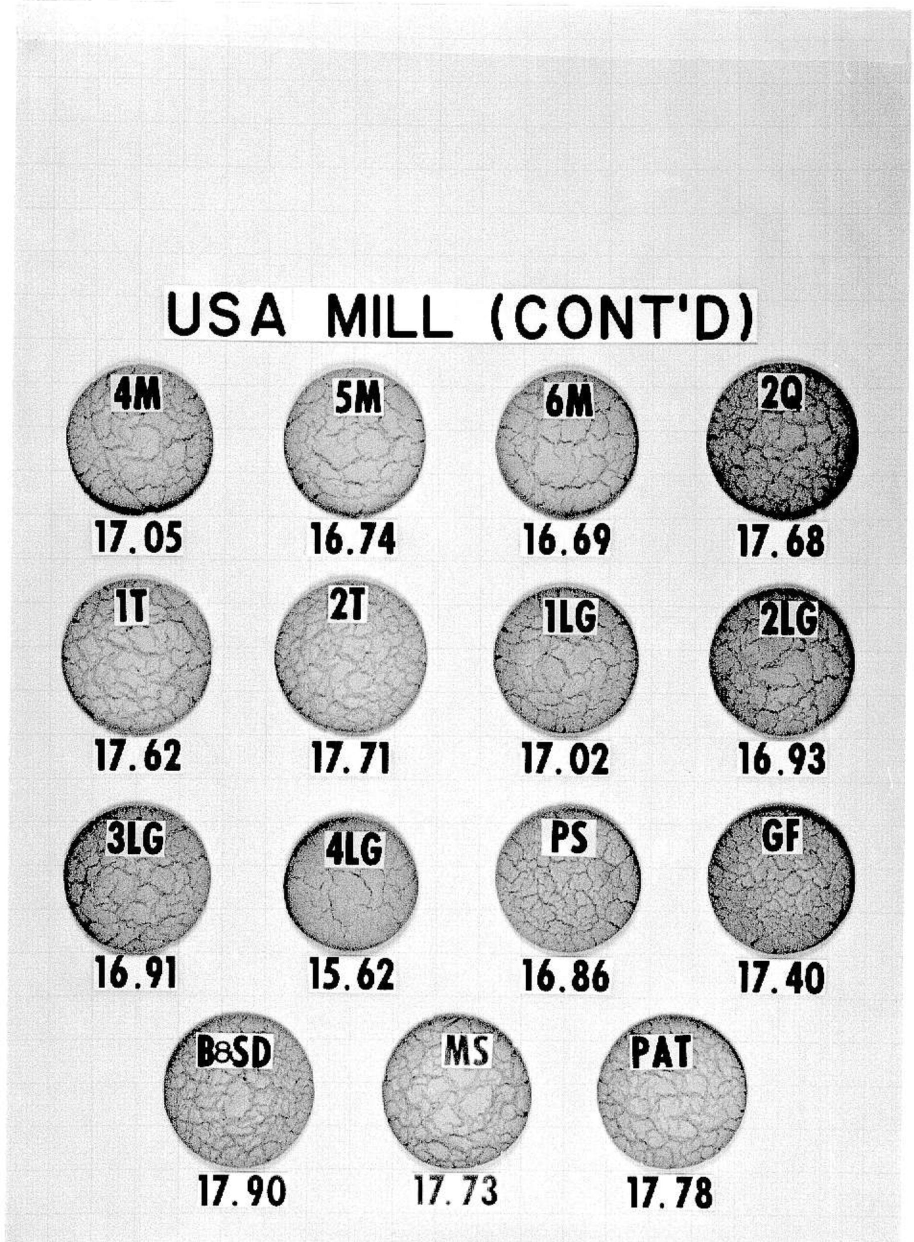

Figure 25B. Baking test of flours from a U.S. commercial flour mill (continued).

Table IX. Mexican Patent Flour (RH1) Milled in Alpine Pin and Ball Mills[1].

Treatment	Tip Speed	Feeding Time	Distance Traveled	Av. Particle Size: Fisher S.S.S.	Av. Particle Size: MSA Whitby	Av. Particle Size: Between 17-35 μ	Acid Viscosity[2]	A.W.R.C.[2]	Cookie: Diameter	Cookie: Top Grain
	ft/min	min.	feet	μ	μ	%	°MacM	%	cm.	Score
Alpine Pin Mill (RPM)										
None	0.0	0.00	0.0	13.7	38	24	62.0	50.19	17.68	8.0
7300	10504.7	2.25	23635.6	12.4	23	30	43.0	51.80	17.57	8.0
9200	13238.8	1.83	24227.0	11.4	22	32	43.0	51.87	17.39	8.0
11200	16116.8	1.16	18695.5	10.7	17	25	42.0	51.90	17.23	8.0
14000	20146.0	0.75	15109.5	9.8	18	36	43.0	52.64	17.19	7.5
14000 (2 passes)	20146.0	1.50	30219.0	9.5	17	35	46.0	55.30	16.75	7.0
Ball Mill (hrs)										
6	--	--	--	9.1	15	25	37.0	67.45	15.37	1.0
24	--	--	--	6.2	13	21	64.0	107.59	13.43	0.0

1/ Moisture, ash, and protein contents were 11.7, 0.36, and 9.1% respectively, (on a 14% moisture basis).

2/ Values reported on a 14% moisture basis.

Granulation was studied using the Alpine pin mill and the ball mill. From Table IX can be inferred that as particle size decreases cookie quality decreases. The variations in cookie diameter confirm the findings of Brenneis (2). Cookie diameter decreased with increasing RPM's of the Alpine pin mill.

It is noteworthy that the action of the ball mill was highly damaging to cookie quality (Fig. 26). Cookies were as poor or poorer than the poor cookie standard.

Table X shows the Farrand starch damage test (7) for the Mexican patent flour treated for different intervals of time in the ball mill. Obviously the very poor cookies representing treatments in the ball mill are attributable to starch damage (refer to Fig. 24B for a reproduction of the cookie from the untreated patent flour).

MSA Whitby sedimentation graphs for different RPM's on the Alpine pin mill and different time intervals on ball mill are shown in Fig. 27. Comparable data for the cookie standards are given in Figs. 28 and 29. Flour granulation tables for all MSA Whitby sedimentation analyses are shown in Appendix I.

Sifting and Air Separation Studies

Clear flour (RH2) and three of its low-ash streams, including first break (T1), sizings (D1) and fourth midds (C4), were sifted on a 15xx bolting cloth to the end point (no further increase in percent of thrus). Quality characteristics of overs and thrus are presented in Table XI. It is noted that the Fisher S.S.S. value for the original flour is always below the average value of overs and thrus. Cookies

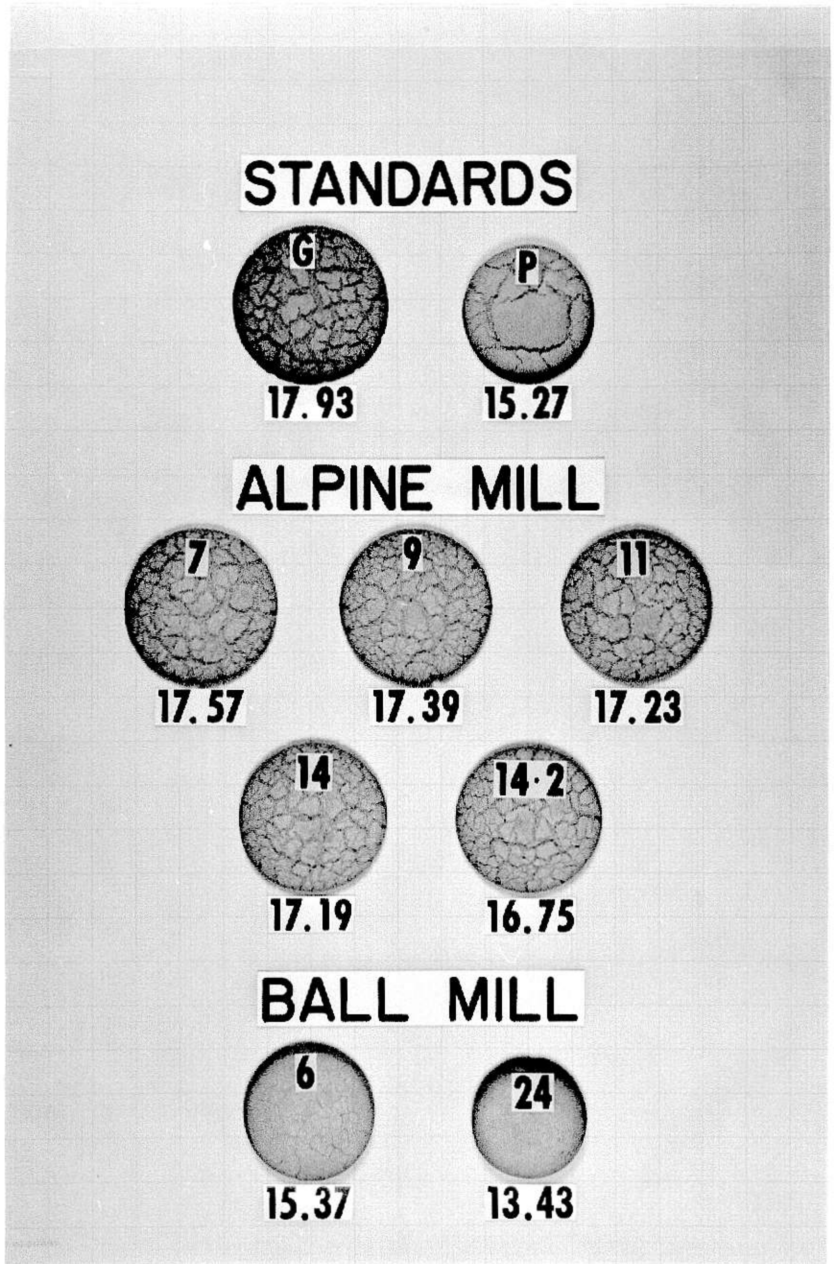

Figure 26. Baking test for patent flour (RH1) treated in Alpine pin mill and ball mill.

Table X. Farrand Starch Damage for Patent Flour (RH1) Milled in the Ball Mill.

Treatment (HRS)	Starch Damage %
None	1.8
6	24.3
24	79.2

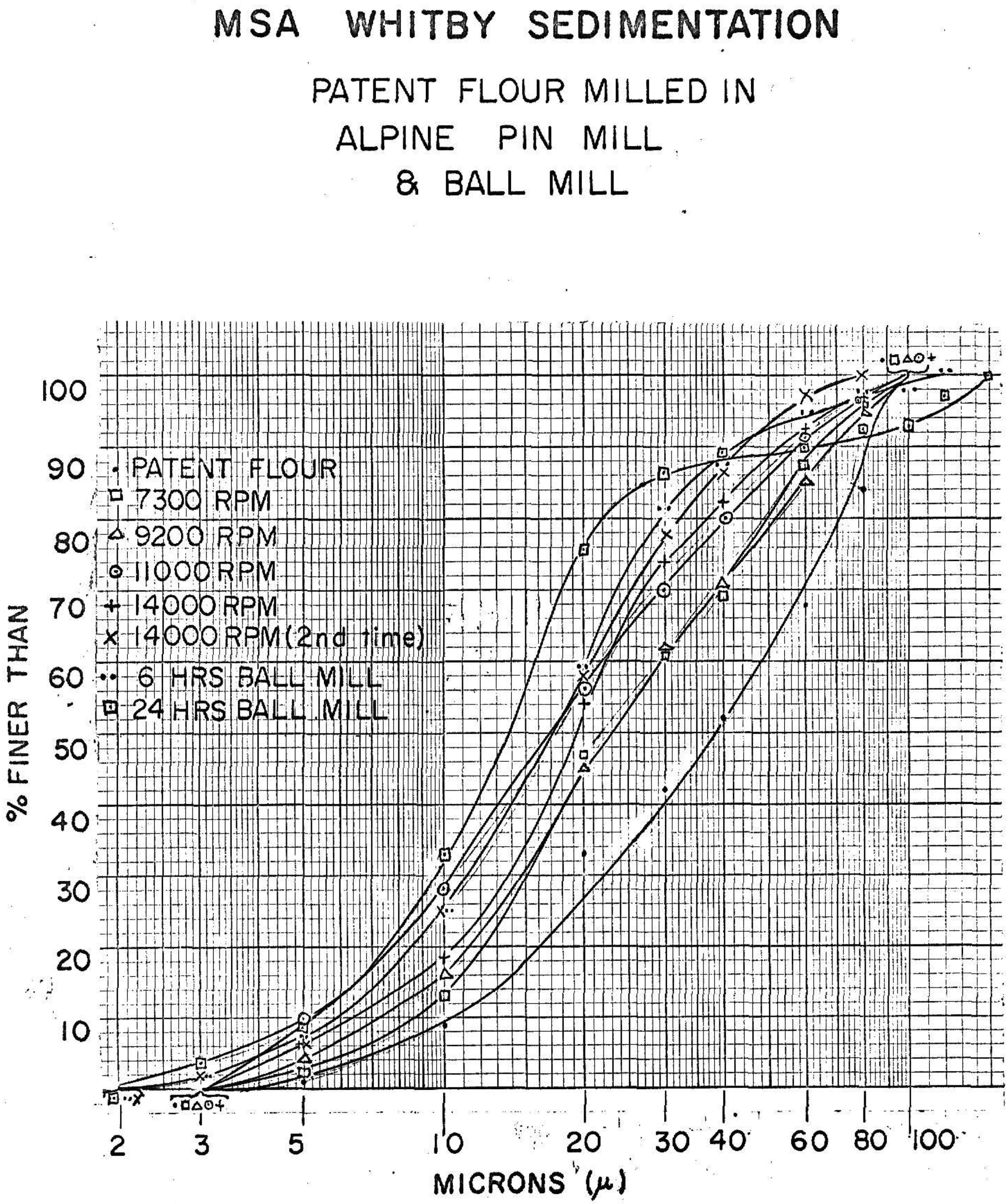

Fig. 27. MSA Whitby sedimentation for patent flour (RH1) treated in Alpine pin mill and ball mill.

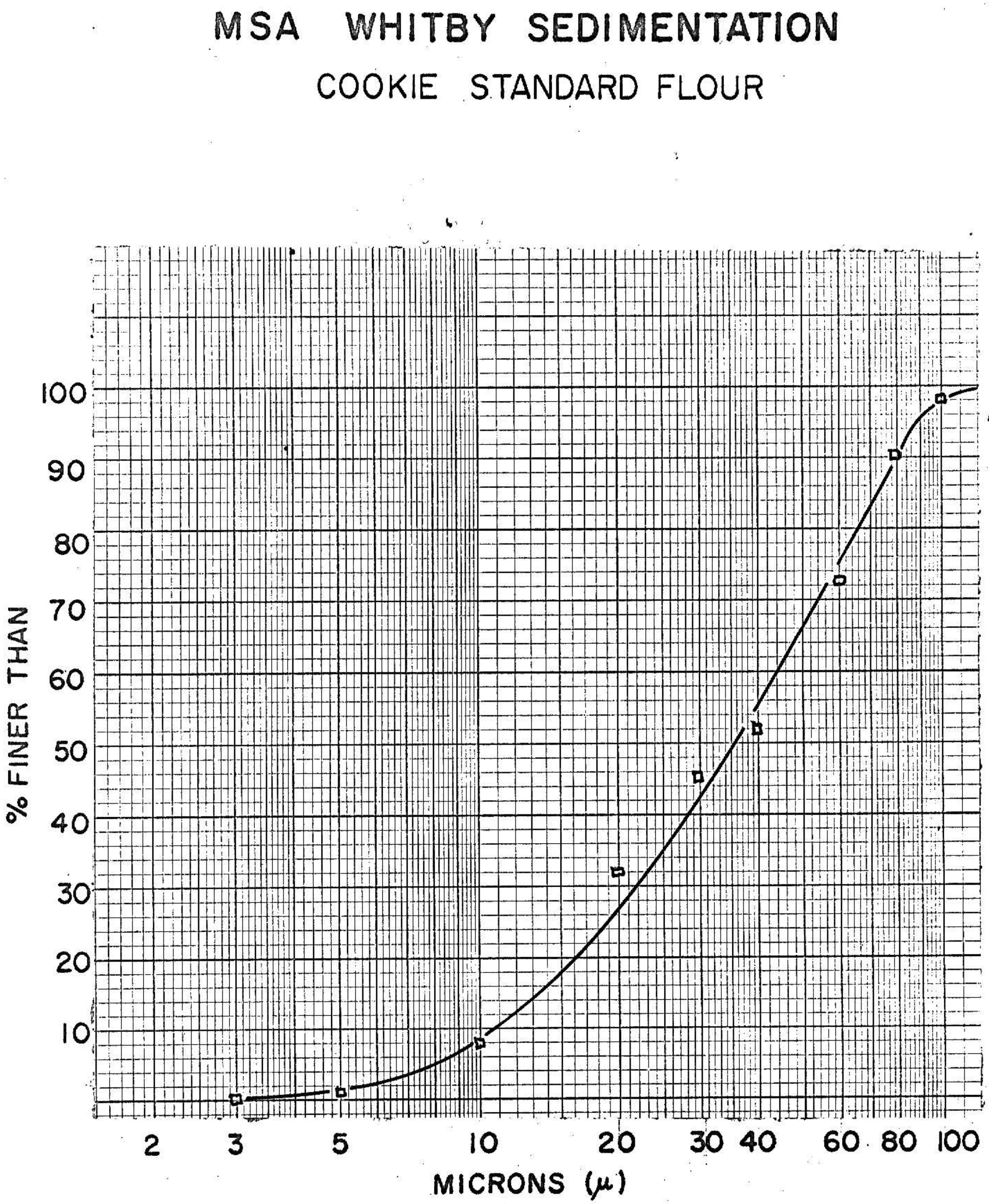

Fig. 28. MSA Whitby sedimentation for good standard flour.

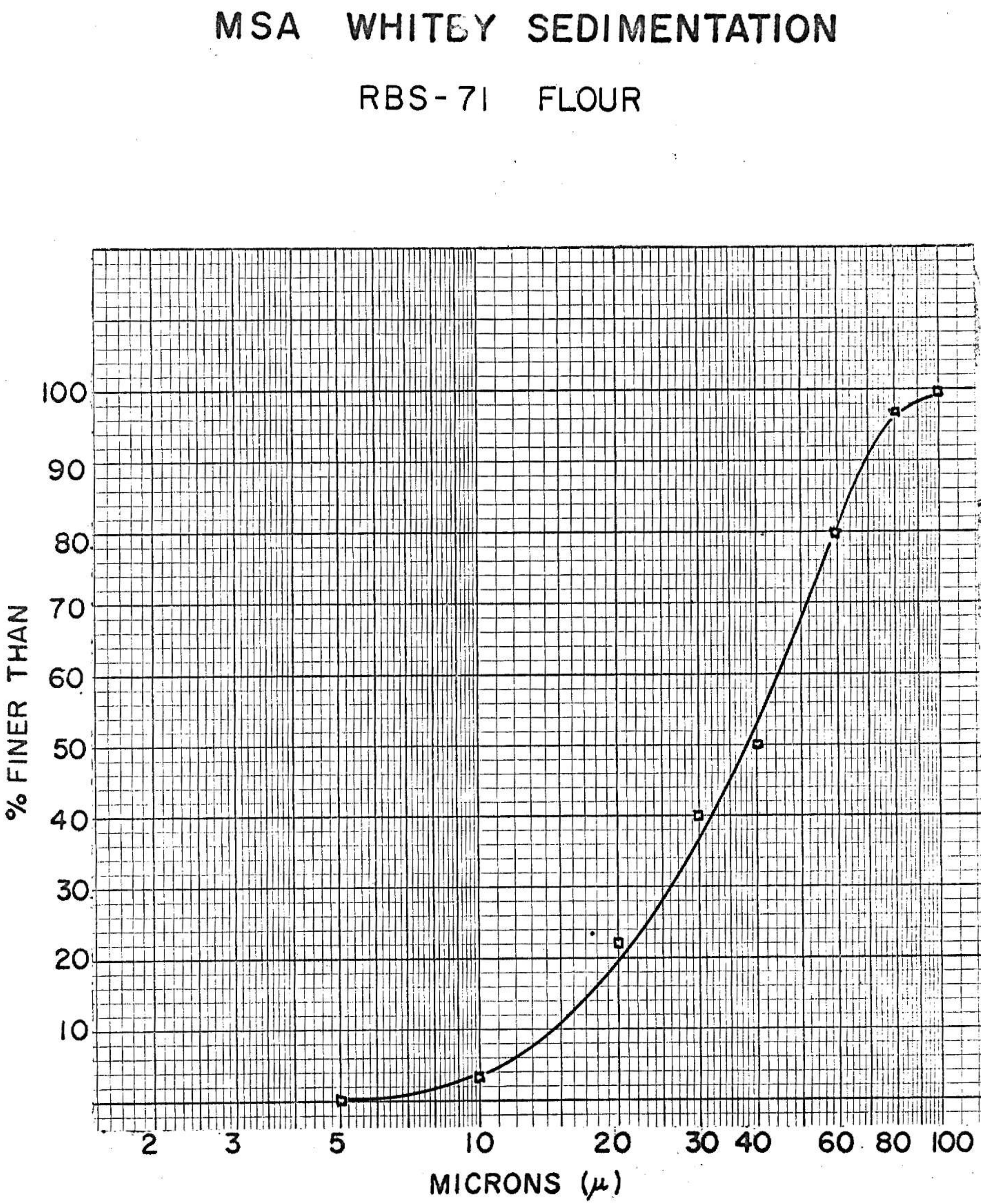

Fig. 29. MSA Whitby sedimentation for poor standard flour.

Table XI. Quality Characteristics of Mexican Clear Flour and Three of its Low-ash Streams Sifted on a 15xx Bolting Cloth.

Flour or Stream	Moisture	Ash[1]	Protein[1]	Av. Particle Size: Fisher S.S.S.	Av. Particle Size: MSA Whitby	Av. Particle Size: Between 17-35 μ	Acid Viscosity[1]	A.W.R.C.[1]	Cookie: Diameter	Cookie: Top Grain Score
	%	%	%	μ	μ	%	°MacM.	%	cm.	
THRUS										
Clear	11.7	0.30	9.4	10.5	17	36	34.0	52.31	17.42	7.0
1BK	12.1	0.38	7.8	11.8	21	47	28.0	41.49	18.21	8.0
SIZ	12.0	0.38	7.4	11.2	20	48	27.0	48.22	17.80	8.0
4M	11.7	0.36	8.2	10.0	18	41	27.0	50.81	17.68	7.0
OVERS										
Clear	11.7	0.51	12.1	27.0	53	16	99.0	64.02	15.96	2.0
1BK	12.1	0.37	10.0	26.4	61	9	97.0	49.17	16.26	4.5
SIZ	11.9	0.41	10.1	22.5	48	15	69.0	51.14	16.68	4.5
4M	12.0	0.38	9.9	25.0	60	11	80.0	55.93	16.61	4.0
ORIGINAL										
Clear	12.1	0.49	10.8	16.0	28	29	63.5	54.12	17.35	7.0
1BK	12.6	0.36	9.5	16.3	31	40	60.0	43.82	18.02	8.0
SIZ	12.6	0.38	8.3	15.3	25	38	38.5	50.02	17.65	8.0
4M	12.6	0.36	9.1	16.5	30	23	57.0	53.45	17.55	7.0

1/ Values reported on a 14% moisture basis.

baked with these flours are represented in Fig. 30. Cookie diameter of the thrus of each sample was greater than corresponding original or overs. Those data are in agreement with the findings of Wichser and Shellenberger (23), namely, that the smaller the particle size, the greater the cookie diameter. MSA Whitby sedimentation graphs for the four original samples separated on a 15xx flour cloth are presented in Figs. 31 to 34.

The same four samples used in the preceding study were passed through a Raymond air separator to obtain coarse and fine products. Their quality characteristics are presented in Table XII. It is noteworthy that the Fisher S.S.S. of the original samples is approximately the average of the coarse and fines. It is noted too that the lower the A.W.R.C. value, the larger the cookie diameter. Cookies baked from those flours are reproduced in Fig. 35. In view of the previous study, it was somewhat surprising to find that the cookie diameter of the coarse fraction of each sample was greater than the corresponding original or fine fraction. Unlike the sieves that take into account particle shape and size, air separation takes into account shape, and density of the particles. Apparently air separation concentrates the starch damage in the fine fraction. The air separation did not appear to make the distinct particle size separation characteristic of sieving. MSA Whitby sedimentation graphs for samples treated on the Raymond air separator can be found in Figs. 36 to 39.

The findings obtained from the air separation test challenge the Wichser and Shellenberger (23) statement regarding the relationship between particle size and cookie quality. It is concluded in this study that other factors, in addition to particle size, may be crucial in cookie quality.

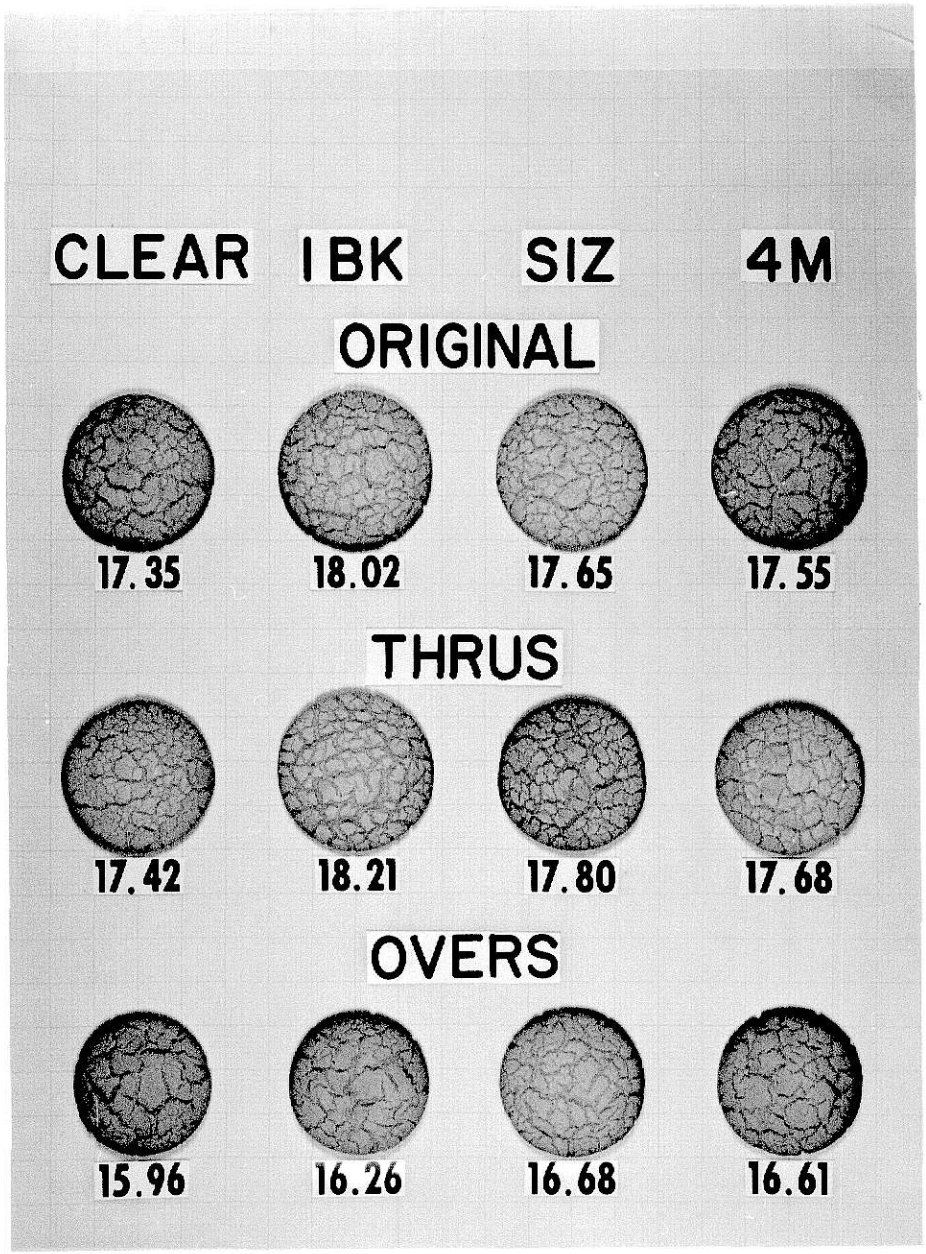

Figure 30. Baking test for clear (RH2), first break (T1), sizings (D1) and fourth midds (C4) flours sifted on 15xx bolting cloth.

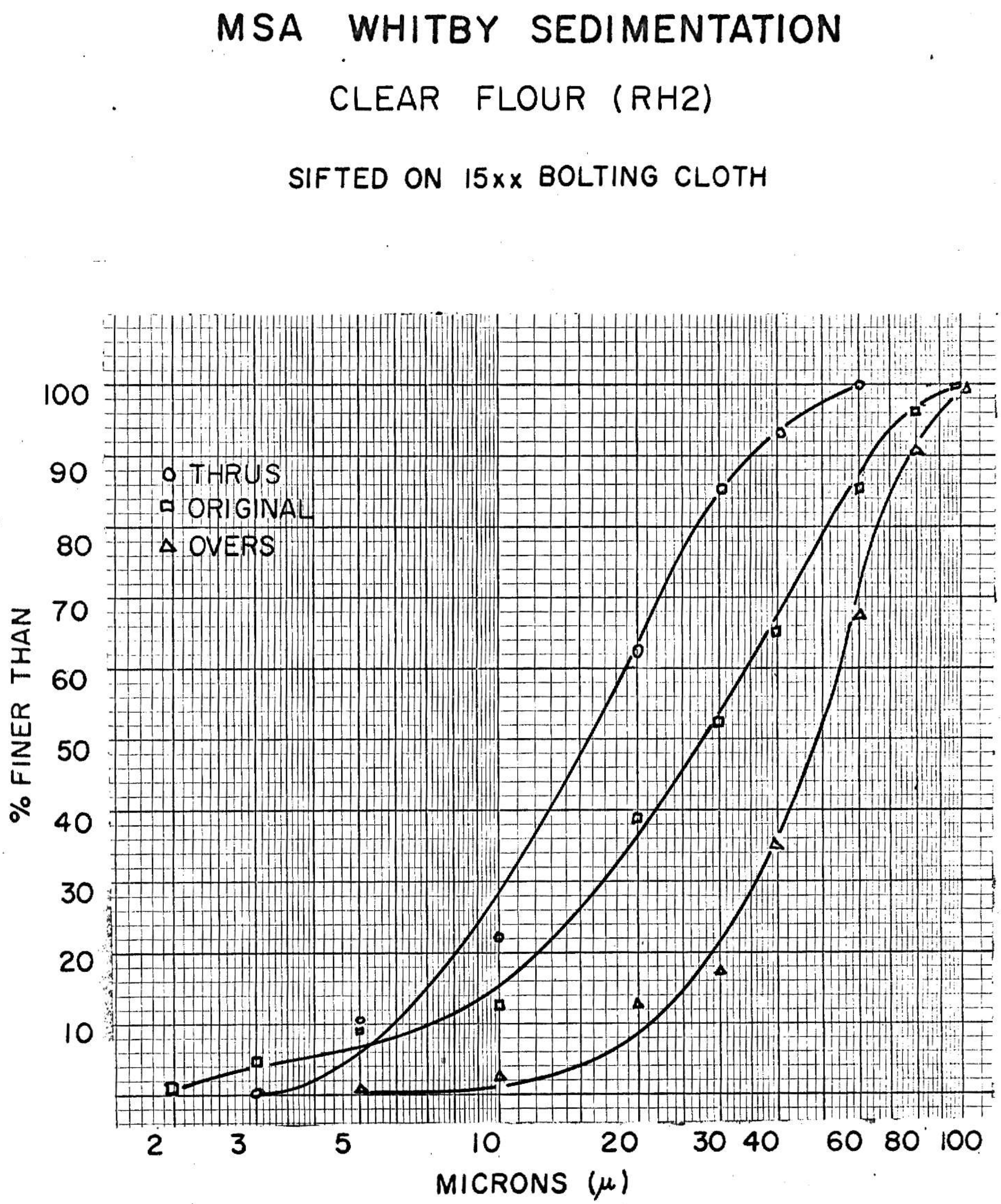

Fig. 31. MSA Whitby sedimentation for clear flour (RH2) sifted on 15xx.

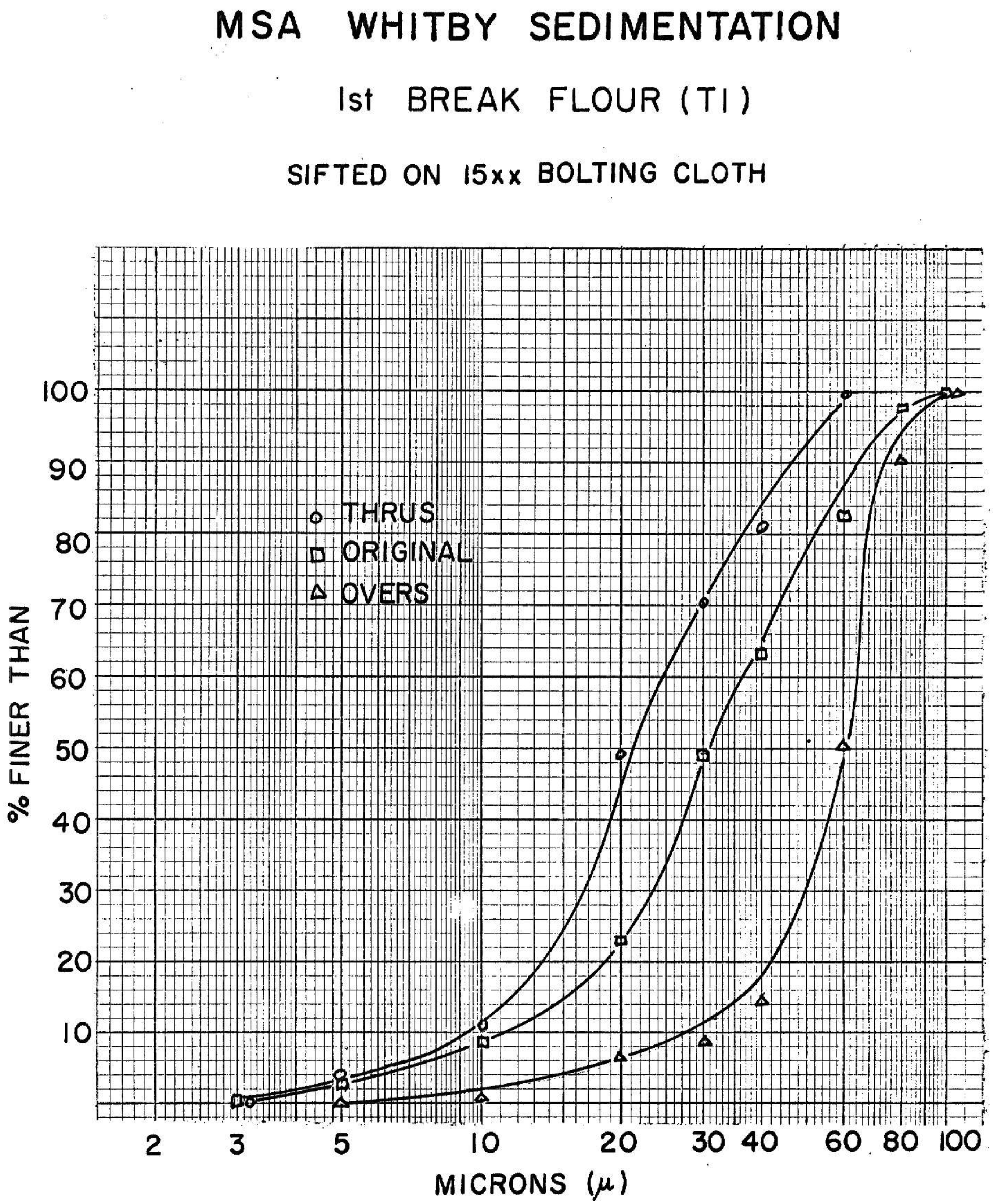

Fig. 32. MSA Whitby sedimentation for first break flour (T1) sifted on 15xx bolting cloth.

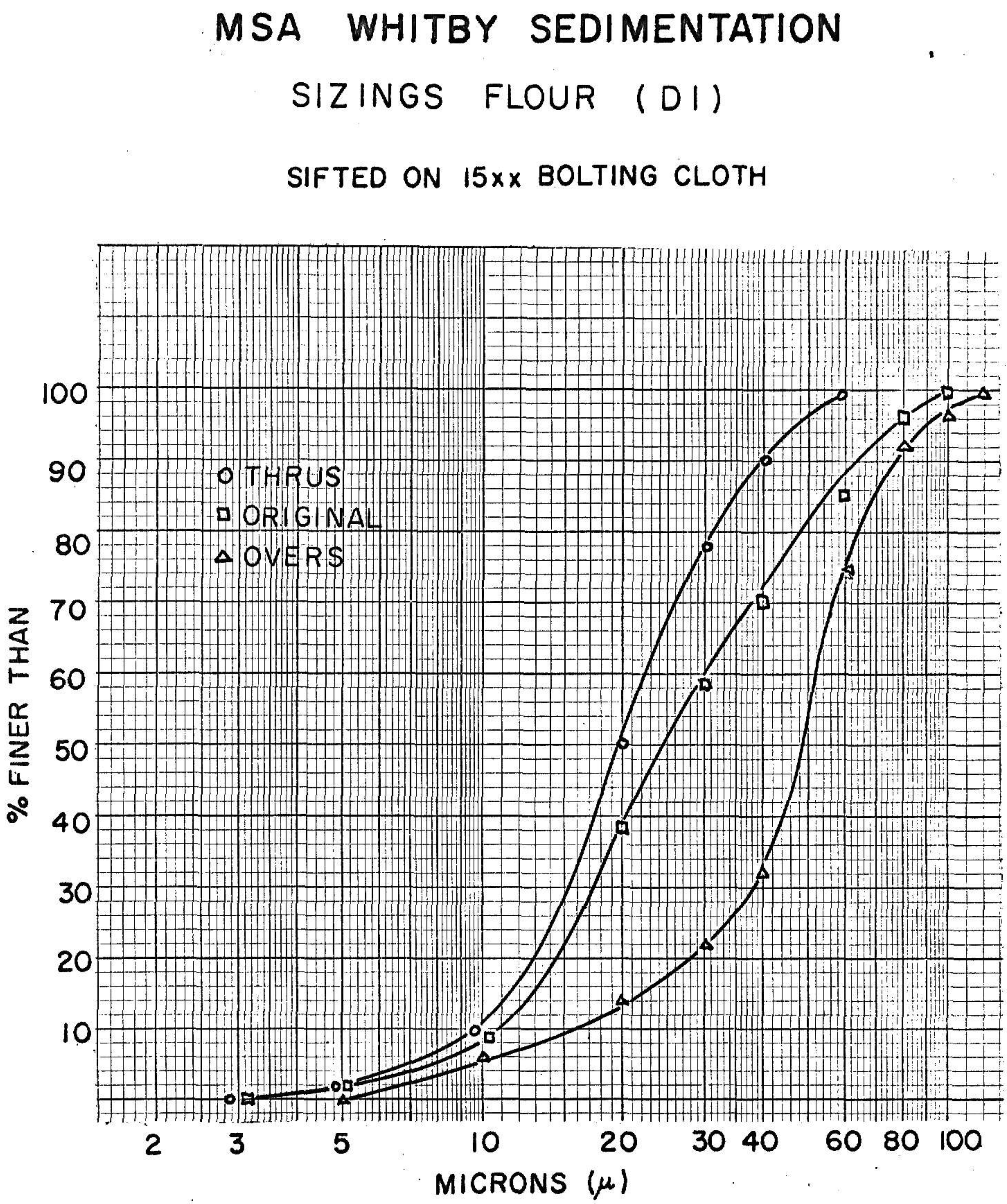

Fig. 33. MSA Whitby sedimentation for sizing flour (D1) sifted on 15xx bolting cloth.

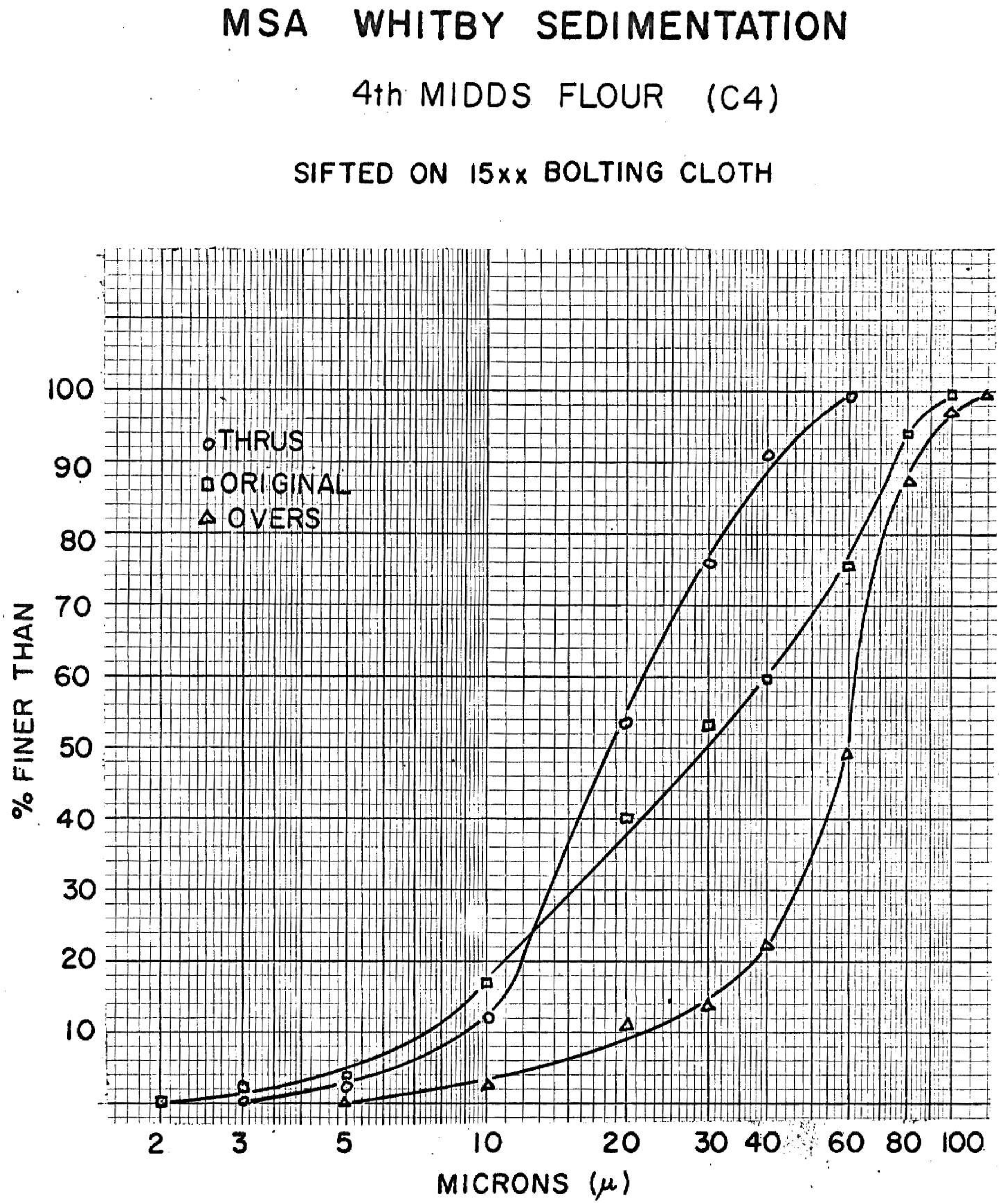

Fig. 34. MSA Whitby sedimentation for fourth midds flour (C4) sifted on 15xx bolting cloth.

Table XII. Quality Characteristics of Mexican Clear Flour and Three of its Low-ash Streams using the Raymond Air Separator.

Flour or Stream	Moisture	Ash[1/]	Protein[1/]	Av. Particle Size Fisher S.S.S.	MSA Whitby	Between 17-35 µ	Acid Viscosity[1/]	A.W.R.C.[1/]	Cookie Diameter	Top Grain Score
	%	%	%	µ	µ	%	°MacM.	%	cm.	
FINES										
Clear	11.2	0.50	10.2	10.7	20	45	39.0	56.87	16.53	5.0
1BK	11.5	0.35	9.7	12.0	20	46	36.0	50.51	17.52	7.5
SIZ	11.4	0.40	8.2	11.8	20	47	24.0	53.59	17.26	6.0
4M	11.3	0.38	8.4	10.0	19	40	36.0	55.85	16.76	7.5
COARSE										
Clear	11.5	0.45	11.1	19.5	58	12	46.0	51.80	17.66	8.0
1BK	11.7	0.38	8.4	22.0	48	18	52.0	40.10	18.11	8.0
SIZ	11.9	0.35	9.3	18.0	46	20	36.0	46.52	17.92	8.0
4M	11.4	0.34	9.5	25.0	60	13	49.0	50.12	17.74	8.0
ORIGINAL										
Clear	12.1	0.49	10.8	16.0	28	29	63.5	54.12	17.35	7.0
1BK	12.6	0.36	9.5	16.3	31	40	60.0	43.82	18.02	8.0
SIZ	12.6	0.38	8.3	15.3	25	38	38.5	50.02	17.65	8.0
4M	12.6	0.36	9.1	16.5	30	23	50.7	53.45	17.55	7.0

1/ Values reported on a 14% moisture basis.

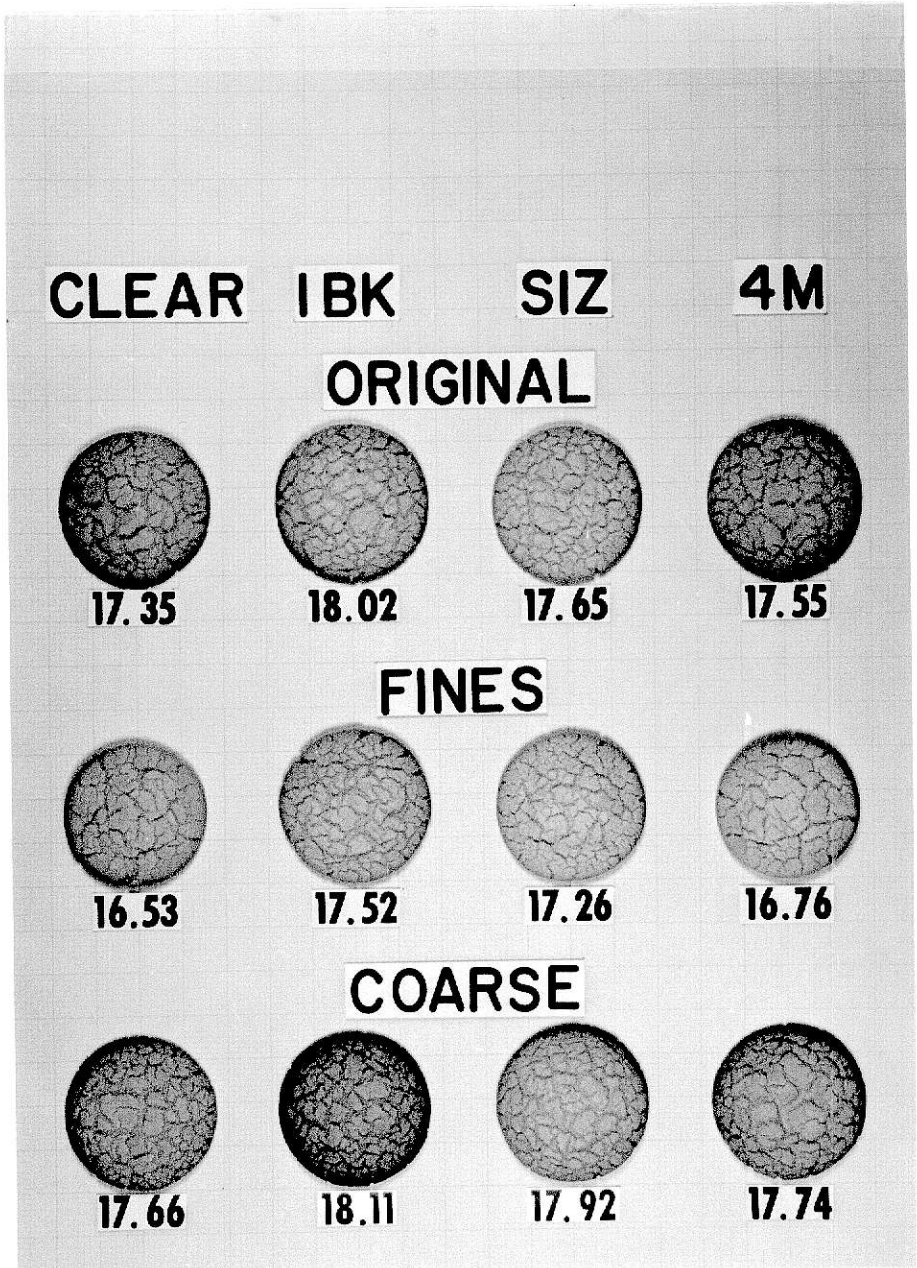

Figure 35. Baking test for clear (RH2), first break (T1), sizings (D1) and fourth midds (C4) flours subjected to the action of the Raymond air separator.

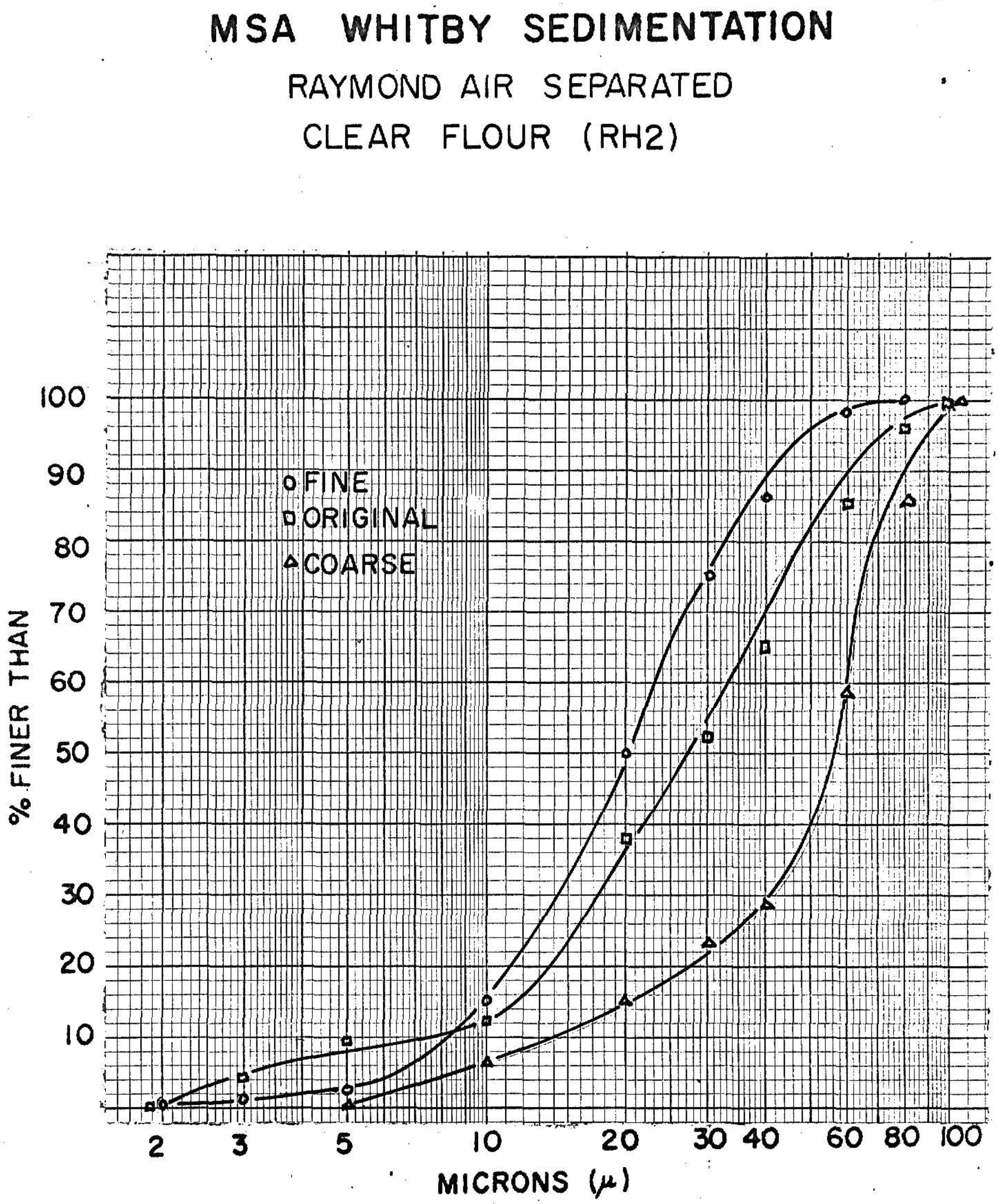

Fig. 36. MSA Whitby sedimentation for clear flour (RH2) using the Raymond air separator.

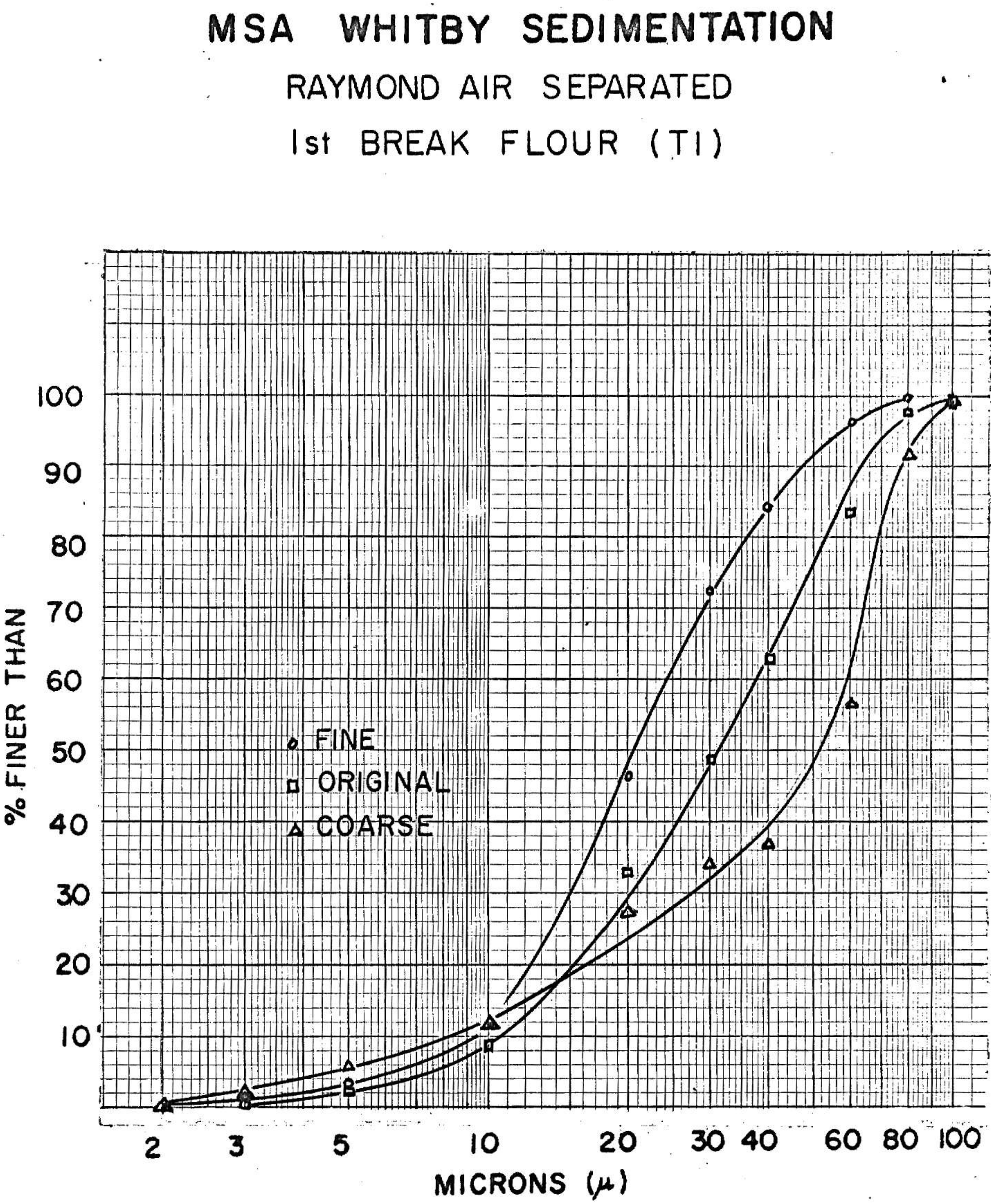

Fig. 37. MSA Whitby sedimentation for first break flour (T1) using the Raymond air separator.

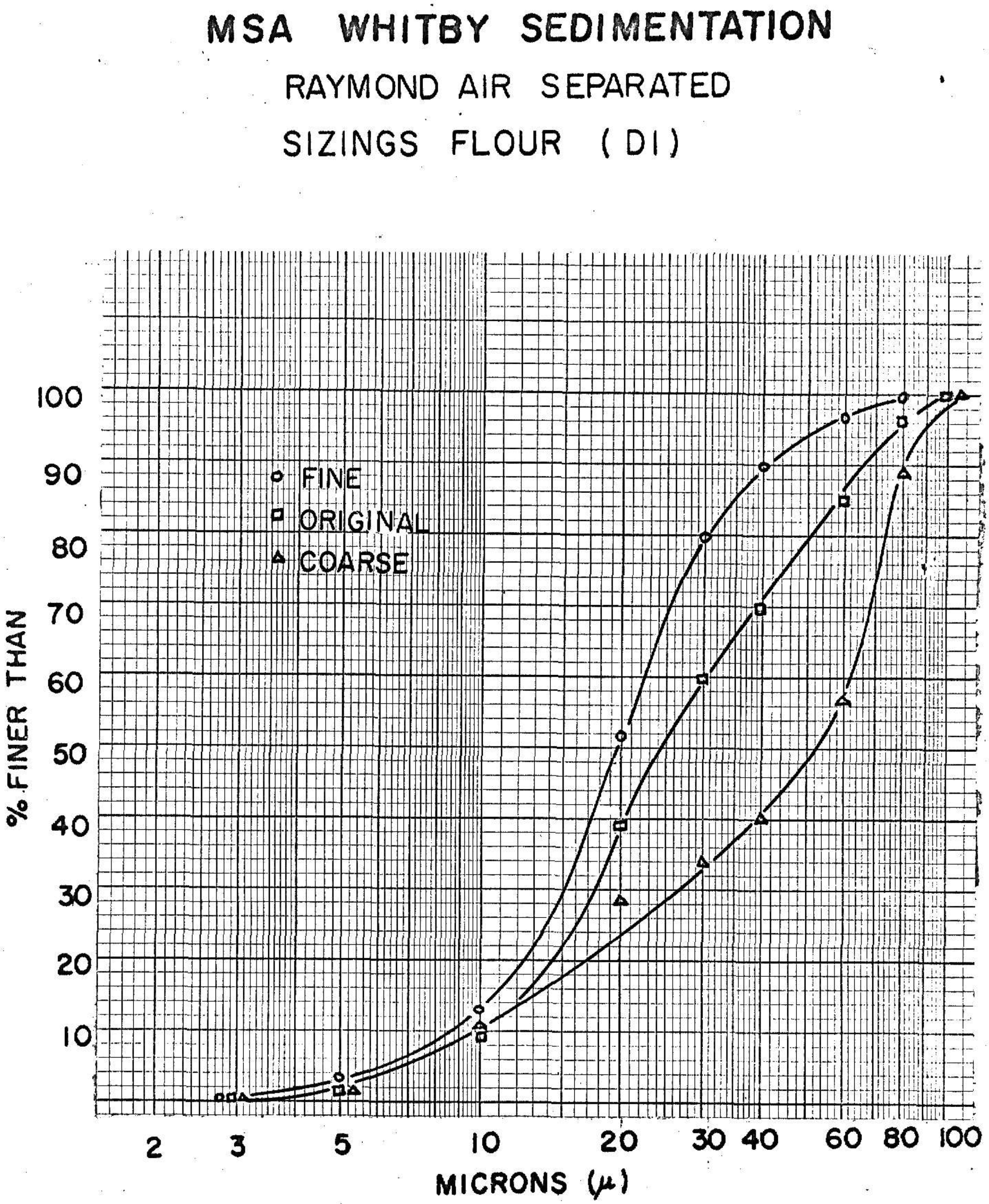

Fig. 38. MSA Whitby sedimentation for sizings flour (D1) using the Raymond air separator.

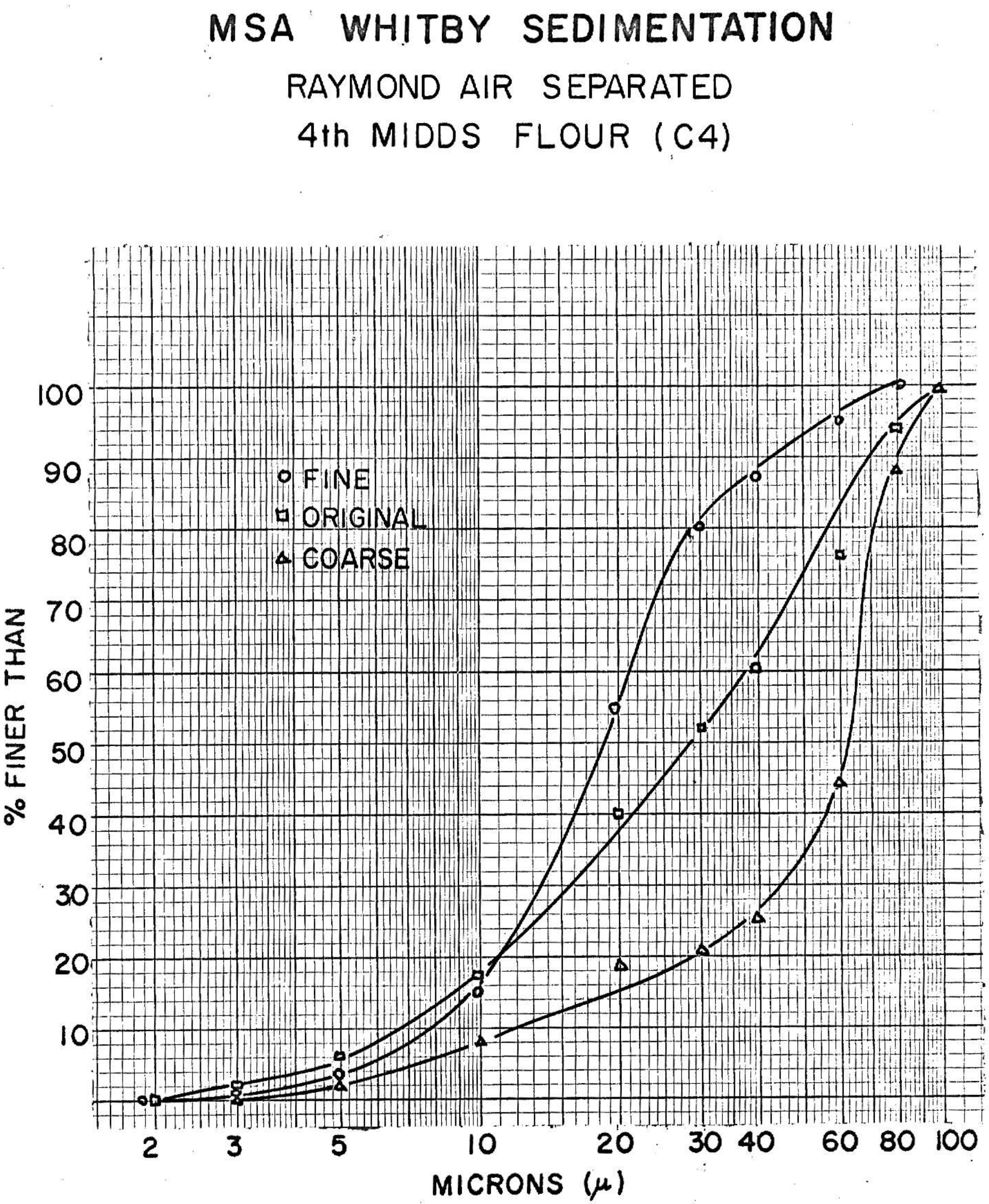

Fig. 39. MSA Whitby sedimentation for fourth midds flour (C4) using the Raymond air separator.

SUGGESTION FOR FUTURE WORK

a) More work could be done in flour granulation studies. Sifting could be study in further separation of thrus and overs, so it will be possible to find out if fine particle size affects positive to cookie quality or other factors are affecting to cookie quality. The same could be checked using those two fine fractions and mixing again them together a cookie quality equal to the original flour should be expected.

b) Another suggestion could be to try to find out an statistical formula based on a regression model which correlate all factors affecting cookie spread; so it will be possible to know the spread of cookies even before baking test is performed.

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APPENDIX I

MSA WHITBY SEDIMENTATION

SIZE ANALYSIS TABLES

Table XIII. MSA Whitby Sedimentation Size Analysis for Standard Flours.

Diameter	Less Than Diameter Good Standard	Less Than Diameter Poor Standard
μ	%	%
100	98.0	99.9
80	90.0	97.0
60	73.0	78.8
40	52.0	49.5
30	45.0	39.4
20	32.0	22.0
10	7.0	3.0
5	0.1	0.1

Table XIV. MSA Whitby Sedimentation Size Analysis for Patent Flour Milled on Alpine Pin and Ball Mills.

Diameter	Less Than Diameter Original	Less Than Diameter 7300 RPM	Less Than Diameter 9200 RPM	Less Than Diameter 11200 RPM	Less Than Diameter 14000 RPM	Less Than Diameter 14000x2 RPM	Less Than Diameter 6 Hours	Less Than Diameter 24 Hours
μ	%	%	%	%	%	%	%	%
160	--	--	--	--	--	--	--	96.9
120	--	--	--	--	--	--	99.0	93.1
100	98.4	--	98.9	99.9	--	99.9	97.9	92.5
80	83.6	96.5	95.0	97.3	97.4	97.5	96.9	91.2
60	67.7	89.7	85.5	90.6	93.4	86.3	95.3	90.6
40	52.5	74.1	70.7	79.8	82.2	78.3	86.5	89.3
30	42.5	65.8	62.4	71.8	74.4	58.4	81.2	87.5
20	33.8	49.5	45.8	56.4	54.6	25.0	68.7	77.1
10	8.0	15.4	15.5	28.0	19.0	7.0	25.5	33.5
5	0.5	0.1	4.2	9.5	6.0	1.3	7.0	7.0
3	0.1	--	0.1	0.1	0.1	0.1	2.7	3.0
2	--	--	--	--	--	--	0.1	0.1

Table XV. MSA Whitby Sedimentation Size Analysis for Mexican Clear Flour Sifted on 15xx Flour Cloth.

Diameter	Less Than Diameter Original	Less Than Diameter Overs	Less Than Diameter Thrus
μ	%	%	%
120	--	--	--
100	99.3	99.1	--
80	96.5	91.3	--
60	84.7	66.0	99.9
40	64.4	27.0	89.9
30	52.8	17.2	86.1
20	38.9	14.5	63.4
10	12.5	5.0	20.2
5	8.8	0.1	10.0
3	4.1	--	0.1
2	0.1	--	--

Table XVI. MSA Whitby Sedimentation Size Analysis for First Break Flour Sifted on 15xx Flour Cloth.

Diameter	Less Than Diameter Original	Less Than Diameter Overs	Less Than Diameter Thrus
μ	%	%	%
120	--	--	--
100	99.0	98.9	--
80	97.9	91.0	--
60	83.8	49.5	98.9
40	62.6	14.7	83.0
30	48.7	8.0	65.0
20	33.1	6.5	41.1
10	8.2	1.2	4.0
5	2.7	0.1	0.1
3	0.1	--	--

Table XVII. MSA Whitby Sedimentation Size Analysis for Sizings Flour Sifted on 15xx Flour Cloth.

Diameter	Less Than Diameter Original	Less Than Diameter Overs	Less Than Diameter Thrus
μ		%	%
120	--	99.3	--
100	99.9	95.6	--
80	96.0	92.7	--
60	85.1	64.5	99.3
40	69.1	32.1	90.0
30	59.5	22.6	78.5
20	38.2	14.3	51.5
10	9.0	6.0	8.0
5	1.1	0.1	2.2
3	0.1	--	0.1

Table XVIII. MSA Whitby Sedimentation Size Analysis for Fourth Midds Flour Sifted on 15xx Flour Cloth.

Diameter	Less Than Diameter Original	Less Than Diameter Overs	Less Than Diameter Thrus
μ	%	%	%
120	--	99.2	--
100	99.9	91.5	--
80	94.6	83.1	--
60	75.7	41.6	99.9
40	59.5	19.2	91.8
30	53.3	13.5	75.5
20	40.0	8.2	54.0
10	17.0	2.7	12.0
5	3.5	0.1	3.0
3	2.0	--	0.1
2	0.1	--	--

Table XIX. MSA Whitby Sedimentation Size Analysis for Mexican Clear Flour on Raymond Air Separator.

Diameter	Less Than Diameter Original	Less Than Diameter Fine	Less Than Diameter Coarse
μ	%	%	%
100	99.3	--	98.8
80	96.5	99.9	85.0
60	84.7	98.3	57.5
40	64.4	86.4	28.5
30	52.8	75.2	23.8
20	38.9	50.8	15.0
10	12.5	14.5	6.4
5	8.8	2.5	0.1
3	4.1	1.0	--
2	0.1	0.1	--

Table XX. MSA Whitby Sedimentation Size Analysis for First Break Flour on Raymond Air Separator.

Diameter	Less Than Diameter Original	Less Than Diameter Fine	Less Than Diameter Coarse
μ			%
100	99.0	99.9	99.9
80	97.9	96.2	91.9
60	83.8	84.7	56.8
40	62.6	72.6	37.0
30	48.7	46.4	34.0
20	33.1	12.0	28.0
10	8.2	2.8	12.6
5	2.7	1.1	5.5
3	0.1	0.1	1.0
2	--	--	0.1

Table XXI. MSA Whitby Sedimentation Size Analysis for Sizings Flour on Raymond Air Separator.

Diameter	Less Than Diameter Original	Less Than Diameter Fine	Less Than Diameter Coarse
μ	%	%	%
100	99.9	99.9	99.0
80	96.0	97.4	89.2
60	85.1	89.4	57.4
40	69.1	79.7	40.5
30	59.5	52.0	34.4
20	38.2	13.0	28.8
10	9.0	3.0	10.0
5	1.1	0.1	1.0
3	0.1	--	0.1

Table XXII. MSA Whitby Sedimentation Size Analysis for Fourth Midds Flour on Raymond Air Separator.

Diameter	Less Than Diameter Original	Less Than Diameter Fine	Less Than Diameter Coarse
μ	%	%	%
100	99.9	--	99.2
80	94.6	99.4	88.4
60	75.7	95.0	44.1
40	59.5	86.3	25.8
30	53.3	79.4	21.7
20	40.0	55.5	18.5
10	17.0	14.8	7.5
5	3.5	3.1	1.5
3	2.0	0.9	0.1
2	0.1	0.1	--

APPENDIX II

AGTRON COLOR IN COOKIES

Agtron color meter model M-300 (Fig. 10, left) was used for study the variations in color of cookies. The instrument has four monochromatic spectral lines: Blue 436 mμ (Hg), Green 546 mμ (Hg), Red 640 mμ (Ne) and Yellow 585 mμ. Blue color was found not to be adequate for this study due to low readings in cookie color. Standard color discs 24 and 81 were used for green, red, and yellow monochromatic lines. The instrument is standarized with standard disc 24 adjusting meter to read 0 and with standard disc 81 adjusting meter to read 100. Color was obtained from bottom and top of the cookie. All cookies baked in the granulation study were used for this color study. Color of cookies is presented in the following tables.

Apparently it seems that spectral lines Red or Yellow can be used to measure the color of the cookies.

Table XXIII. Agtron Color Cookies from Mexican Wheat Varieties.

Wheat	Green Bottom	Green Top	Red Bottom	Red Top	Yellow Bottom	Yellow Top
Mexican						
Lerma Laguna	17.0	50.0	58.0	85.5	33.8	67.0
Lerma Jimenez	16.5	58.0	58.0	90.0	33.5	73.5
Barrigon	33.0	61.0	75.0	95.0	51.0	77.5
Penjamo Chihuahua	17.1	56.0	59.0	90.0	34.0	72.6
Penjamo Region	21.0	58.0	63.0	93.0	38.0	75.0
Inia	30.0	54.5	72.0	91.5	48.0	72.0
7 Cerros	24.0	53.1	66.5	90.5	42.5	71.0
No. 1	24.5	66.5	68.0	98.0	43.0	82.0
Blend	8.0	53.5	48.0	88.0	23.1	70.0
Standards						
Good	13.7	48.0	54.0	81.2	28.6	61.9
Poor	21.9	59.0	64.8	91.0	39.0	74.0

Table XXIV. Agtron Color of Cookies from Mexican Flour Mill Streams.

Flour or Stream	Green		Red		Yellow	
	Bottom	Top	Bottom	Top	Bottom	Top
1BK	22.8	61.0	63.5	90.3	39.0	75.0
2BK	17.2	57.9	58.5	89.4	33.7	73.0
1-2 BK GR	25.2	54.2	55.5	86.5	30.7	69.0
3BK	21.6	63.5	62.0	95.0	38.0	82.0
3BK GR	22.0	60.0	64.0	91.8	39.0	75.8
4BK	19.6	60.1	60.4	91.5	35.8	75.5
5BK	17.0	63.3	57.8	91.2	33.0	76.0
SIZ	26.0	68.6	67.0	95.8	42.8	81.8
1M	22.2	63.0	64.5	94.7	39.7	78.5
2M	21.0	62.0	63.0	93.0	38.0	77.8
3M	23.0	62.2	64.8	94.0	40.0	78.0
4M	14.5	59.3	56.2	91.0	30.0	74.2
5M	16.0	55.2	57.5	89.0	32.1	71.5
6M	15.1	58.0	57.0	91.1	31.3	74.3
7M	11.6	51.9	51.9	84.8	27.1	67.5
8M	18.7	58.0	60.0	90.0	35.5	73.6
9M	25.0	58.9	64.5	86.3	42.3	72.0
10M	19.9	52.9	60.0	85.4	56.2	68.5
Good Suction	20.0	64.8	60.0	92.8	35.6	78.9
Poor Suction	14.9	53.0	54.6	84.0	31.0	68.0
LG	16.6	53.2	56.0	84.5	33.0	68.0
Patent	17.0	58.0	59.0	90.0	34.0	73.2
Clear	15.0	55.5	56.0	88.5	30.4	70.3
Good Standard	13.7	48.0	54.0	81.2	28.6	61.9
Poor Standard	21.9	59.0	64.8	91.0	39.0	74.0

Table XXV. Agtron Color of Cookies from USA Flour Mill Streams.

Flour or Stream	Green		Red		Yellow	
	Bottom	Top	Bottom	Top	Bottom	Top
1BK	16.0	56.3	55.5	87.2	32.0	71.5
1BK GR	21.8	55.0	61.9	86.5	38.0	70.5
2BK	21.0	63.5	62.5	92.0	37.0	71.5
3BK	26.0	67.2	67.0	94.8	43.8	81.8
2-3 BK GR	24.0	65.0	65.9	94.5	41.0	79.0
4BK	22.0	64.2	62.5	89.5	38.9	77.0
5BK	19.0	58.0	59.9	88.0	35.0	73.0
A SIZ	21.7	62.0	64.5	94.0	39.0	78.0
1M	18.0	54.5	61.0	89.0	34.2	70.0
2MC	18.5	59.8	62.0	94.5	35.0	75.5
2MF	23.8	58.5	67.0	94.0	41.0	75.0
3M	15.9	55.2	59.5	93.0	32.5	72.0
4M	16.0	60.0	60.0	95.8	33.0	77.0
5M	23.0	64.4	65.5	95.5	41.0	80.9
6M	21.8	61.3	64.0	94.0	39.0	78.0
1T	20.6	63.5	64.0	95.0	37.0	78.0
2Q	12.0	48.0	53.1	83.6	27.8	64.0
Poor Suction	12.5	50.0	52.5	81.0	28.0	64.0
1LG	16.7	52.8	58.8	87.4	34.7	69.6
2LG	13.1	49.0	54.0	83.0	29.5	65.0
3LG	14.4	52.0	55.2	85.0	30.8	68.0
4LG	10.5	49.0	51.0	80.0	26.0	62.2
Germ Flour	18.0	48.0	54.7	83.0	29.0	64.9
Midd Scalps	18.1	56.5	60.0	91.0	34.8	75.1
2T	16.0	62.0	58.8	92.0	33.0	77.0
B & SD	15.0	54.9	54.5	83.8	30.0	69.0
Cookie Flour	22.0	60.5	63.0	90.0	39.0	75.0
Good Standard	13.7	48.0	54.0	81.2	28.6	61.9
Poor Standard	21.9	59.0	64.8	91.0	39.0	74.0

Table XXVI. Agtron Color of Cookies from Alpine Pin and Ball Milled Flours.

Treatment	Green Bottom	Green Top	Red Bottom	Red Top	Yellow Bottom	Yellow Top
Alpine Pin Mill (RPM)						
7300	14.0	57.1	54.6	89.0	30.7	74.0
9200	16.5	58.9	57.0	90.5	33.8	76.0
11200	9.8	58.3	49.0	90.3	25.2	75.7
14000	18.1	61.2	59.0	93.0	35.0	78.5
14000 (Second Time)	11.0	58.6	50.5	91.2	27.0	75.3
Ball Mill (HRS)						
6	15.0	63.4	55.9	93.0	32.0	78.8
24	6.7	37.8	41.3	67.0	20.2	50.8
Standards						
Good	13.7	48.0	54.0	81.2	28.6	61.9
Poor	21.9	59.0	64.8	91.0	39.0	74.0

Table XXVII. Agtron Color for Cookies from Flours Sifted on 15xx Flour Cloth.

Flour	Green		Red		Yellow	
	Bottom	Top	Bottom	Top	Bottom	Top
<u>Thrus</u>						
Clear	17.6	63.0	58.0	93.5	33.2	78.0
1BK	17.8	59.0	58.9	89.2	34.0	73.8
SIZ	13.8	50.1	54.3	87.2	29.5	67.3
4M	16.2	67.3	57.1	98.0	32.7	82.2
<u>Overs</u>						
Clear	25.9	49.0	56.8	84.2	32.0	65.0
1BK	21.5	44.2	63.0	89.1	38.0	70.8
SIZ	20.0	56.7	61.5	91.0	36.3	73.0
4M	17.1	50.8	59.0	88.0	33.7	68.0
<u>Standards</u>						
Good	13.7	48.0	54.0	81.2	28.6	61.9
Poor	21.9	59.0	64.8	91.0	39.0	74.0

Table XXVIII. Agtron Color for Cookies from Flours Treated in the Raymond Air Separator.

Flour	Green		Red		Yellow	
	Bottom	Top	Bottom	Top	Bottom	Top
Fines						
Clear	21.9	63.7	62.8	93.6	39.0	78.2
1BK	15.1	59.8	56.0	90.0	31.0	74.2
SIZ	19.9	67.0	61.0	96.5	36.0	82.0
4M	23.9	69.9	65.5	99.8	41.0	85.0
Coarse						
Clear	20.3	55.6	62.2	88.2	37.0	71.8
1BK	9.0	41.4	48.5	79.6	24.0	59.0
SIZ	25.1	57.0	67.0	89.9	42.1	72.5
4M	20.3	52.0	62.0	88.0	36.8	69.0
Standards						
Good	13.7	48.0	54.0	81.2	28.6	61.9
Poor	21.9	59.0	64.8	91.0	39.0	74.0

PHYSICAL, CHEMICAL, PHYSICAL-CHEMICAL, MILLING AND BAKING (COOKIE) PROPERTIES OF MILL-STREAMS AND THEIR FLOURS FROM MEXICAN WHEATS THAT VARY IN HARDNESS AND OTHER QUALITY CHARACTERISTICS

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The object of this study was to evaluate the cookie quality of Mexican wheat varieties and flour streams from a Mexican commercial mill. Eight Mexican wheat varieties and one blend were subjected to chemical and physical tests and experimental milling. The texture of those eight wheats were characterized as soft, medium, and hard. The blend was a mixture of 90% soft Lerma Laguna and 10% No. 1 hard wheats.

Flours obtained from the Mexican wheat varieties, 21 flour streams plus patent and clear flours from a commercial Mexican flour mill, and 26 flour streams plus a patent flour from a commercial U.S. flour mill were subjected to chemical, physical, physicochemical, and baking tests.

Two U.S. straight-grade flours were used as standards. A soft wheat flour (good cookie standard) was obtained from the Federal Soft Wheat Quality Laboratory (Wooster, Ohio); and a hard wheat flour (RBS-71, poor cookie standard) was obtained from the Hard Winter Wheat Quality Laboratory (Manhattan, Kansas).

Test weight per bushel of the Mexican wheat varieties was not a good index of flour yield; and pearling index did not accurately predict kernel texture. Break flour yield, however, was a good index of kernel texture (relative hardness).

In the baking studies Lerma Laguna and Lerma Jimenez produced the best cookies. Penjamo Region and Penjamo Chihuahua also possessed good cookie quality. Straight-grade flour from Barrigon, 7 Cerros, No. 1, and Inia wheats possessed poor cookie quality.

The best streams for a cookie flour from the Mexican flour mill were selected. Factors affecting the selection included relatively low viscosity, low alkaline water retention capacity (A.W.R.C.), large cookie diameter, and high top grain score. The classification of U.S. commercial mill streams, used for comparison, differed from that of the Mexican mill streams.

Granulation was studied with the ball and Alpine pin mills. The action of both mills were highly damaging to cookie quality.

Mexican clear flour and three of its low-ash streams were used in sifting and air separation studies. Cookie diameter of the thrus (fine fraction) of each sample was greater than the corresponding overs or original unsifted sample. In view of those results, it was surprising to find that the cookie diameter of the coarse fraction of each sample subjected to air separation was greater than the corresponding fine fraction or original sample. Apparently air separation concentrates damaged starch in the fines and does not appear to make the distinct particle size separation that is characteristic of sieving.

It is concluded in this study that factors other than particle size may be crucial in cookie quality.