A COMPARATIVE STUDY OF WORLD WHEATS

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by

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INTRODUCTION

The relative milling and baking quality of world wheats is of interest to all wheat producing countries. The large exporting countries particularly are desirous of knowing how their wheats compare with competing wheats from other parts of the world.

The marked superiority of Canadian hard red spring wheat, from the standpoint of bread baking quality, has long been recognized, and other countries less fortunate in the production of high quality wheat, both on account of less favourable climatic conditions, and the lack of varieties of suitable inherent characteristics, have held the Canadian wheat as a model, the quality of which may be approached if not actually equalled.

A period of economic nationalism has forced plant breeders throughout the world to place more and more importance on this quality factor. Western European countries are striving to produce wheat of such quality that the importation of Canadian grain will be unnecessary. South Africa and New Zealand have a similar objective. Danubian countries aim at improving the quality of their wheat, thereby regaining some of their lost markets in the more Western European countries. Argentine wishes to raise the quality of at least a portion of its wheat crop from the "filler" to the "carrier" standard and so compete with Canada on a more equal footing.

In Australia for many years new varieties of wheat have been bred solely from the point of view of high yielding capacity, quality having been completely overlooked. The past decade has seen the appearance and rising popularity of a large number of new varieties many of which are distinctly inferior to the older varieties which have been largely displaced due to their poorer yielding capacity, or their inability to resist the attacks of rust and flag smut. Notable amongst these newer varieties are Nabawa, foremost in popularity in New South Wales, and Western Australia, and Free Gallipoli the most popular wheat in Victoria, and fifth in the order of popularity in New South Wales. Other new varieties which are now popular are Bobin, Waratah and Sepoy. All of the above are inferior to the old Federation which they have replaced, and it is significant that Club wheat appears in the pedigree of several. Gluclub, a very popular wheat in Western Australia, is of Club wheat parentage and has probably been largely responsible for the decrease in quality of Western Australian wheat.

Yield then has been increased at the expense of quality, and unquestionably the standard of Australian shipments has fallen off in recent years. The realization of this fact and the continued complaints from all sections of the wheat and flour trade in Australia, have resulted in a reversal of policy, and the importance of quality is now fully recognized.

It is doubtful whether Australia could ever produce wheat equal in quality to Canadian hard red spring, as the environment is unfavourable for the production of wheat of high protein content. Nevertheless it is possible to produce wheat of the "filler" standard, and if Australia is to retain its present overseas markets it is essential that there should be some improvement in quality.

It seemed advisable at the outset to make the study reported herein to find exactly how Australian export shipments compare with those of other countries and, further to discover where some of the newer Australian varieties fall in the scale of quality.

HISTORICAL

Although English workers have had considerable experience in the laboratory testing of world wheats, and have from time to time published some general considerations on the different classes of wheat, the only complete study on this subject reported in the literature is that of Coleman et. al.(1)

This classic paper, though of great value, is open to severe criticism, in the light of present knowledge, in that only one baking test was used, the formula including neither a diastatic supplement nor a chemical improver such as ammonium persulphate or potassium bromate. Present day workers knowing the inadequacy of the basic procedure of the American Association of Cereal Chemists, as a single test of baking quality, must discount entirely the baking results expressed in this paper, as the procedure used was such as to give results essentially similar to what would be given by the above mentioned test.

It is now realized that a number of baking tests are necessary before experimentally milled flours may be placed in order of "strength" or more explicitly "potential baking quality".

For a loaf to be of optimum volume and appearance, it is necessary that the yeast in the dough be adequately supplied with yeast food in the form of fermentable sugars and essential salts, and that the gluten or protein complex be in such a physical condition that what is known as a "mature" loaf is produced. A loaf which is "green" or underfermented or which shows the appearance of "age" or overfermentation does not have the maximum volume which the flour is capable of producing.

The recognition of these facts has led to the elaboration of a large number of supplementary baking procedures which have materially increased the accuracy with which one may predict "strength".

As early as 1925 Werner[2] was using a "pup" loaf baking test which was the forerunner of the present American Association of Cereal Chemists' method. He suggested the use of potassium bromate in order that additional information may be gained. The value of this procedure was commented upon by Herman[3] who however preferred to use Arkady. It was incorporated in the Standard Experimental Baking Test as supplementary procedure C by Blish[4]. Larmour and McLeod[5] and Larmour[6] pointed out the usefulness of the test in giving a more accurate measure of quality than the basic procedure when applied to hard red spring wheats of western Canada. Bayfield and Shiple[7] and Bayfield[8] and Jorgenson[9] have shown that not only is this supplementary procedure applicable to the better quality spring and winter wheats, but that it is very valuable and in fact necessary in evaluating the baking quality of soft wheats. Geddes[10] has shown the usefulness of the test in the case of over-matured or damaged flours. The writer has found that Australian wheats show a positive response in the main, which, though of a small magnitude, nevertheless produces the appearance of correct fermentation desirable when the bread is being judged. It has been found that the judging of "green" loaves is very difficult and the differences between flours have been accentuated by resorting to the bromate procedure.

The well known definition of flour strength of Humphries[11] was modified by Kent-Jones[12] in 1924 to read "Strength is the ability of flour to be converted into large well piled loaves, provided any deficiency in the rate of gas production in the dough stage is supplemented in a suitable manner". Many flours particularly when experimentally milled are deficient in diastatic activity and consequently gassing power. In such cases the basic procedure of the American Association of Cereal Chemists does not adequately supplement the "deficiency in the rate of gas production in the dough stage". The procedure used by Coleman(1) in his work could be critized on the same grounds.

Though for many years malt flour was used as a diastatic supplement in the Dominion Grain Research Laboratory, Markley and Bailey(13) first drew attention to the need for a modification of the experimental baking test to allow for a supplementary procedure for use with low diastatic flours. The use of a diastatic supplement either as malt flour or malt extract is now almost universal, and in many cases the original basic procedure has been totally abolished in favour of a malt supplementary test. Larmour and Brockington(14) indicate that such a supplement is necessary when potassium bromate is used to determine tolerance to oxidizing agents, a malt bromate supplementary test being necessary rather than the simple bromate test.

A further modification of the use of diastatic malt is the inclusion of ammonium acid phosphate in the formula. Larmour and Brockington(15) show that the addition of 0.1% (NH_4) H_2PO_4 gives the maximum loaf volume obtainable. The malt-phosphate and the malt-phosphate-bromate tests were subsequently adopted by the "Associate Committee on Grain Research" of the National Research Council of Canada. Geddes and McCalla(16) have compared the bromate and the malt-phosphate-bromate formulae in testing wheat quality in plant breeders samples, showing the superiority of the latter.

To aid in the differentiation of flours which may not easily be separated otherwise Larmour and Brockingto (17) have suggested a formula in which fermentation is maintained at a high rate, sufficient fermentable sugar (6%) being included in the formula as to make any further diastatic supplement unnecessary. Considerable success has since resulted from the use of this "high yeast-high sugar-bromate" test.

The importance of the degree of mixing on loaf volume was early recognized, and in 1928 a standard mixing procedure was specified for the basic baking test of the American Association of Cereal Chemists, and provision was made for variation in mixing procedure in supplement "D".

The use of dough mixing machines simplified the standardization of mixing procedure, but the machines in use were not suited to studies of mixing tolerance, until the mixer described by Swanson and Working[18] was modified to make it possible to fit it as an attachment to the Hobart machine. Merrit, Blish and Sandstedt[19] following an extensive investigation favoured the use of the Swanson machine, and the Committee on the Standardization of the Experimental Baking Test (Geddes[20]) recognized both the Hobart and the Hobart Swanson machines official. Aitken and Geddes[21] made use of the Hobart-Swanson mixer in studying mixing tolerance. At the University of Minnesota all flours are baked by a malt supplementary procedure using mixing times of 2 and 5 minutes in order to arrive at an estimate of mixing tolerance.

The elaboration of the various baking procedures outlined above has given the cereal chemist a series of tests of proven value by which he may differentiate flours on a basis of baking quality with reasonable confidence.

METHODS OF ANALYSIS USED

Where not otherwise specified the methods of analysis used were those of the A.A.O.A.C. Estimation of diastatic activity were made by the method of Blish and Sandstedt[22]. Carotenoid pigments were determined by the method outlined by Ferrari[23,24].

Five baking procedures were used, the ones chosen being those found to give maximum differentiation between flours. It was decided not to use the "Basic Procedure" as the results are of doubtful value with experimentally milled flours of poor diastatic activity.

The baking procedures used were.

1. Malt-phosphate.	) Mixing period 3 minutes	
2. Malt-phosphate-bromate	) at second speed in a two	
3. High yeast-high sugar-bromate	) hook Hobart machine.	
4. Formula 2	1 min. mixing period	) Hobart Swanson
5. Formula 2	3 mins. mixing period	) Machine

The two latter procedures were used to obtain information on the mixing tolerance of the flours, the malt phosphate bromate formula being chosen for this purpose as being if anything superior to the malt phosphate. The weight of flour taken for each test was 100 grams on a 13.5% moisture basis, and low form pans were used. Otherwise the procedure followed was that outlined by Geddes[20]. All flours were baked in duplicate a few days after milling, duplicate tests being carried out on different days.

SOURCE OF SAMPLES

With the exception of the Italian and New South Wales samples, all the wheats included in this study were taken from commercial shipments. In such cases the district from which the wheat originated, if it could be discovered, is recorded (Table I).

Unless otherwise specified the samples were secured by the Canadian Trade Commissioners in London, Paris, Hamburg, etc. The United States samples were obtained through the co-operation of Dr. D.A. Coleman of the United States Department of Agriculture. The New South Wales samples were forwarded by the New South Wales Department of Agriculture, having been collected by Mr. H. Wenholz, Director of Plant Breeding.

Table I shows the wheats examined, grouped according to the country of origin. Data as to the origin or variety, date and place of collection, predominating class and dockage, etc., are included.

With the exception of sample Nos. 1 and 8, and the Italian samples, all are presumably of the crop year 1934.

The New South Wales samples are four varieties which have greatly increased in popularity in recent years. With the exception of Pusa 4 they are of recent origin and although considered to be of superior quality to many of the varieties grown, they owe their increase in popularity largely to their agronomic value.

Pusa 4, which is of Indian origin, has long been recognized as New South Wales best quality commercial variety, but it appears to be unsuitable except within a comparatively small area in the northwest. In 1934-35, 42,393 acres, or 1 per cent of the total area of New South Wales, were sown to this variety. Ford, which is now second in popularity, occupied 12.5 per cent of the total area or 513,399 acres in the same season. This represents an increase of 10 per cent of the total area in two seasons, which has been due partly to an appreciation of its quality but mainly to its rust resistance. Its pedigree is complex but it owes its quality to Fife and Indian parentage. Dundee and Baringa, which have an acreage of 111,679 (2.7 per cent of total) and 38,400 (0.9 per cent) respectively, are of quite recent origin, and have made very rapid headway since their introduction.

It is hoped that the increase in cultivation of these four varieties will soon bring about an improvement in the baking quality of New South Wales export wheat.

TABLE I.

Description of Wheat Samples Analyzed.

Lab. No.	Origin or Variety	Date and Place of Collection	Predominating Class	Dockage %	Wt. per 1000 Kernels	Remarks
Argentina						
1	Buenos Aires	Buenos Aires Aug. 1933	Hard Red Winter	1.5	26.4	
2	Bahia Blanca Barletta &/or Russo	London Feb. 1935	"	3.0	29.2	Sl. smutty
3	Barletta &/or Russo Buenos Aires	" "	"	2.0	34.0	
4	Upriver	" "	"	1.5	32.8	
5	"	" "	"	1.5	33.6	
6	Rosafé	" "	"	1.0	32.2	
7	"	" "	"	1.5	36.0	
Australia						
8	Mixed sample 1928-29 crop	Kent-Jones 1929	Soft White	-	38.0	
9	West. Australia F.A.Q.	London, Feb. 1935	"	1.0	38.8	
10	South " "	(1934-35 crop)	"	1.0	34.5	
11	Victoria "	"	"	1.5	38.0	
Austria						
12	Lower Austria	Hamburg, Mar. 1935	Hard Red Winter	2.0	34.8	
Canada						
13	Winnipeg, Av. Man. No. 1 Hard	Winnipeg Grain Inspection Office	Hard Red Spring	-	28.8	
14	" No. 1 Northern	April, 1935.	"	-	27.2	
15	" No. 2 "	"	"	-	26.2	
16	" No. 3 "	"	"	-	26.4	
17	" No. 4 "	"	"	-	26.2	
18	Vancouver Av. No. 1 Northern	"	"	-	26.4	
19	" No. 2 Northern	"	"	-	26.2	
20	" No. 3 "	"	"	-	29.6	
21	" No. 4 "	"	"	-	28.4	
England						
22	English red F.A.Q.	London, Mar. 1935	Soft Red Winter	-	43.6	
France						
23	Somme District	Paris, Mar. 1935	Soft Red Winter	-	46.4	
24	Loire Inferieure	" "	"	1.0	49.2	
Germany						
25	Magdeburg District	Hamburg, Mar. 1935	Soft Red Winter	1.5	40.8	
26	Holstein District	" "	"	1.0	38.8	
Hungary						
27	Kalocsa District	Hamburg, Mar. 1935	Soft Red Winter	2.0	31.6	
28	Gyor District	" "	"	0.5	39.6	

TABLE I (CONT'D)

Lab. No.	Origin or Variety	Date and Place of Collection	Predominating Class	Dockage %	Wt. per 1000 kernels	Remarks
Italy						
29	Var. Montana	Milan, 1932	Soft Red Winter	0.5	33.2	
30	" Villa Glori	"	"	1	27.6	
31	" Ardito	"	"	-	32.0	
32	" Fausto Sestini	"	Hard Winter	-	37.2	
33	" Rieti	"	Soft Red Winter	-	47.2	
34	" Vittorio Veneto	"	"	-	26.2	
Russia						
35	-	Hamburg, Mar/35	Hard Red Winter	2	49.2	Very slight musty odour
36	-		"	2	36.8	
United States						
37	#1 Dark Hard Winter	Washington, D.C. May/35	"	2	22.0	
38	#2 Hard Winter		"	1	25.6	Slightly smutty
39	#1 Soft Red Winter	"	Soft Red Winter	0.5	37.2	
40	#1 Dark Northern Spring	Minneapolis May/35	Hard Red Spring	-	24.5	
41	Northern Spring	"	"	-	25.2	
42	White Club	Portland, Ore. May/35	White Club	-	26.8	
43	Hard White		HardWhite	-	34.0	
44	"	"	"	-	33.6	
45	Soft White	"	Soft White	-	36.0	
Yugo Slavia						
46		Rotterdam March/35	Soft Red Winter	3	36.8	Large number of leguminous seeds impossible to separate by ordinary means.
New South Wales, Australia						
47	Pusa 4 Condobolin Exp. Farm	Sydney, Feb. 1935	Hard White	-	39.8	Some grains black tipped
48	Ford "	"	Soft White	-	47.6	
49	Baringa Trangie Exp. Farm	"	Hard White	-	38.8	Shrivelled bran.
50	Dundee "	"	"	-	37.6	"

Note: In many cases dockage had been removed before the samples were received. For example the Canadian samples were drawn from the averages of the inspection offices which are made up from samples from which dockage has been removed.

MILLING DATA AND ANALYTICAL RESULTS.

Table II shows the milling data and the results of routine analyses on the wheat and flour milled therefrom. The samples are grouped according to country of origin, the countries being arranged in alphabetical order.

MILLING DATA

After the removal of dockage all samples were brought to 13.5% moisture 24 hours before milling. After scouring they were again tempered one half an hour previous to milling, the amount of water added at the second tempering being varied according to the type of wheat. Hard red spring and hard red winter wheats were tempered to 15% moisture, but the soft winters and white wheats were only brought to 14% moisture.

The flow sheet followed was that used by the Dominion Grain Research Laboratory, a straight grade flour being milled, the length of extraction being determined by the colour of the feed flour which is compared with a standard. With wheats of different classes and colours it was found rather difficult at times to conform to a standard, and for the white wheats a different standard was of course necessary.

Flour yield is expressed as percentage of total products, the two figures given in Table II being total yield (including feed flour) and the yield of flour through a 10XX silk. On account of the remarkable uniformity in moisture content of the flours, it was considered unnecessary to correct yield to a 13.5% moisture basis.

Of the 46 samples included in Table II, 28 were milled in duplicate, the standard deviation of the distribution of differences between duplicate millings being 0.42% for total flour and 0.39% for flour through a 10XX silk. On the basis of these results a difference in flour yield of two samples greater than 0.8% might be taken as significant (5% point).

To simplify the recording of results the milling characteristics of each sample were considered as a whole, and expressed as "ease of milling". In cases where the endosperm could only be removed from the bran coat with difficulty, and the middlings did not feed or dress easily, the wheats were classed as poor or very poor. The best milling wheats were described as excellent.

The hard red spring wheats of Canada and the United States were the most easily milled. The endosperm was easily removed from the bran; there was very little break flour; and the middlings were easily ground and dressed. The high grade Canadian wheats gave a better flour yield than the U.S. samples but it will be noticed that in the case of the Winnipeg "averages" the flour yield decreased with grade whereas the yields of the Vancouver "averages" were constant with the exception of No. 4 Northern which was 1% lower than the others. This may be ascribed to the fact that the lower grades of the Winnipeg Averages had more frosted and immature kernels than the corresponding Vancouver Averages which had apparently been graded low on account of the large amount of yellow-berry. One would expect these samples to give a higher flour yield than ones containing many frosted and immature kernels. Lab. No. 1 was fully equal to the spring wheats in ease of milling and was greatly superior to the other Argentine samples. The two Russian samples were also excellent milling wheats. These were followed by the U.S. hard red winters and the remaining Argentine samples excluding Lab. No. 5. The flour yields of the U.S. Hard winters were very good but the yields of the Argentine wheats (with the exception of Lab. No. 1) were much lower.

The Australian wheats although yielding a soft flour were of relatively good milling quality; the bran was easily removed and cleaned and there was not the excessive quantity of break flour often given by soft wheats of other countries. The stocks dressed fairly readily but

TABLE II.

Milling Data and Chemical Properties of World Wheats.

Lab. No.	Bushel Weight Cleaned Wheat	Flour as % Total Products: Total	Flour as % Total Products: Through 10 XX	Ease of Milling	Flour Texture	Flour Moisture %	Pelshenke Time mins.	Protein Wheat %	Protein Flour %	Ash %	Diastatic Activity	Carotenoid Pigments pts/million
Argentina												
1	64	78.6	74.6	Excel't.	Granular	14.0	140	12.2	11.4	.46	116	1.50
2	63	74.4	68.1	V.good	"	13.1	84	11.4	10.5	.44	112	2.19
3	64	74.1	67.3	V.good	"	13.1	47	11.1	10.0	.42	104	1.76
4	62.5	73.9	67.3	Good	Soft	13.7	42	13.0	11.9	.45	76	1.62
5	62.5	72.6	65.2	Fair	"	13.0	39	13.8	12.8	.47	62	1.90
6	64	73.2	67.7	Good	"	13.3	79	12.0	10.8	.48	90	1.70
7	64	73.4	67.7	V.good	Granular	13.6	120	12.6	11.4	.49	108	1.48
Australia												
8	65.5	78.5	73.5	Good	Soft	12.6	63	10.0	9.2	.43	90	1.57
9	64	75.6	71.2	"	"	13.5	42	9.8	9.2	.39	94	2.52
10	61.5	74.6	68.4	"	"	13.3	72	10.5	9.6	.39	90	2.27
11	61.5	74.5	68.0	Fair	"	13.2	43	10.0	9.0	.40	98	2.38
Austria												
12	62	73.2	66.6	Fair	Soft	13.5	40	9.9	8.8	.46	108	3.12
Canada												
13	65.25	76.5	71.0	Excel't	Granular	13.5	196	13.8	13.5	.38	100	1.81
14	64.25	75.8	70.7	"	"	13.3	192	13.7	13.5	.40	110	1.94
15	64	75.4	70.2	"	"	13.6	171	13.8	13.3	.42	115	2.02
16	64	74.7	69.4	V.good	"	13.1	168	12.4	12.1	.43	132	2.16
17	64.5	74.1	66.7	"	"	13.0	140	12.5	11.9	.45	152	2.05
18	63.5	76.2	71.7	Excel't	"	13.5	135	14.2	13.6	.38	114	1.96
19	63.5	76.8	71.9	"	"	13.6	196	13.2	12.1	.45	158	2.29
20	65	76.8	71.9	"	"	13.4	169	11.2	10.9	.45	180	2.16
21	64.5	76.0	70.9	"	"	13.1	140	11.8	10.8	.46	198	2.13

TABLE II (CONT'D)

Lab. No.	Bushel Weight Cleaned Wheat	Flour as % Total Products: Total	Flour as % Total Products: Through 10 XX	Ease of Milling	Flour Texture	Flour Moisture %	Pelshenke Time mins.	Protein Wheat %	Protein Flour %	Ash %	Diastatic Activity	Carotenoid Pigments pts/million
England												
22	64	75.8	70.1	Poor	V.soft	13.2	41	9.2	8.0	.40	82	2.60
French												
23	63.5	77.6	71.6	Poor	Soft	13.8	45	9.6	8.2	.42	82	2.30
24	64	77.7	72.6	"	"	13.4	38	10.1	8.9	.42	84	1.98
Germany												
25	63.5	74.5	68.8	Fair	Soft	14.0	36	10.3	9.3	.38	68	2.16
26	63.5	75.1	70.0	"	"	14.1	35	9.1	8.3	.41	66	2.07
Hungary												
27	62.5	73.8	68.6	Good	Granular	13.8	58	10.7	10.0	.42	120	2.40
28	66	76.0	71.0	V.good	"	13.7	40	12.6	11.8	.41	120	1.86
Italy												
29	61	76.3	71.3	Fair	Soft	13.3	65	9.7	8.9	.46	64	1.34
30	60	74.6	69.5	Poor	"	13.2	61	9.1	8.1	.39	58	1.49
31	59.5	75.0	69.0	"	"	13.0	64	11.3	10.4	.43	58	1.95
32	62	75.2	71.6	Fair	"	13.5	73	10.7	9.3	.45	66	1.88
33	64	76.0	70.7	Poor	"	13.2	66	10.3	9.1	.45	62	1.93
34	58	74.0	69.9	V.poor	V.soft	13.3	61	11.2	10.0	.42	46	2.95
Russia												
35	65.5	77.1	71	Excel't	Granular	14.0	180	13.2	12.3	.48	126	1.61
36	65	77.1	71	"	"	13.9	127	13.2	12.4	.50	126	1.62
United States												
37	65.75	78.3	73.3	V.good	Granular	13.4	69	12.7	12.0	.47	114	1.87
38	65.75	75.8	70.7	"	"	13.6	58	11.3	10.8	.43	160	2.23

TABLE II (CONT'D)

Lab. No.	Bushel Weight Cleaned Wheat	Flour as % Total Products: Total	Flour as % Total Products: Through 10XX	Ease of Milling	Flour Texture	Flour Moisture %	Pelshenke Time mins.	Protein: Wheat %	Protein: Flour %	Ash %	Diastatic Activity	Carotenoid Pigments pts/million
United States (Cont'd)												
39	66.0	77.9	73.1	Good	Soft	13.2	58	11.3	10.5	.38	78	2.00
40	62.5	75.5	69.9	Excel't	Granular	13.6	200	14.6	14.0	.50	110	2.23
41	63.0	74.2	69.8	"	"	13.7	250	12.3	12.1	.50	162	1.81
42	64.0	74.6	70.3	Fair	Soft	13.5	21	8.5	7.7	.37	74	2.29
43	64.5	71.3	65.4	Poor	V.soft greasy	12.6	32	12.5	11.4	.43	74	1.59
44	64.0	70.4	65.2	Poor	V.soft	12.5	36	12.7	11.0	.38	72	1.46
45	63.5	74.2	70.2	Fair	Soft	13.1	36	8.0	6.6	.38	114	2.35
Yugoslavia												
46	60.0	74.1	68.4	V.poor	V.soft	13.1	44	9.4	8.4	.45	74	2.71
New South Wales, Australia												
47	65.75	77.1	72.6	V.good	Granular	13.8	135	13.2	12.6	.38	178	2.23
48	61.75	76.2	72.3	Good	Soft	13.1	85	12.9	11.4	.38	58	2.23
49	63.75	77.9	73.0	Excel't	Granular	13.3	35	13.0	12.2	.47	178	1.79
50	61.0	76.7	72.4	"	"	13.5	79	13.1	12.1	.48	156	2.07

tended to become rather "woolly" at the "tail" of the mill. Considered in relation to bushel weight the flour yield was very good.

The Hungarian samples were good milling wheats yielding a granular flour, but they gave a slightly lower yield than the Australian wheats. The United States soft red winter wheat was equal to the Australian and Hungarian wheats in ease of milling and gave a high percentage of flour. The English, French, German and Italian wheats and also the United States soft white and white Club, although giving in many cases good flour yields, were all of relatively poor milling quality.

Contrary to expectations the United States hard white wheats from the Pacific coast were of poor milling quality. The writer feels that perhaps these wheats require rather special treatment as with the ordinary tempering procedure (to 14% moisture) the bran could not be properly cleaned, a comparatively thick layer of greasy flour adheri g to it. Both samples yielded a large proportion of break flour and the middlings were difficult to grind and dress. The finished flour was very soft and possessed a greasy feel.

The Yugo-Slavian wheat contained approximately three (3%) per cent of leguminous seeds which could not be removed by the ordinary cleaning apparatus. These seeds gave the flour a yellow colour, a rather strong odour, and made it greasy to feel.

PELSHENKE DOUGH TEST

The Pelshenke dough test has shown a certain amount of promise as a test of wheat quality. Bayfield[25,26] has summed up the literature on this subject and from his own experience considers it is of some value for differentiating between rather widely varying types of wheat. It was thought that as most world wheats of commercial importance were included in this investigation, it would be a good opportunity to ascertain the value of this test as a means of predicting baking quality.

Pelshenke times for the wheats examined are given in Table II. The longest times were given by the United States and Canadian hard red spring wheats which were closely followed by the Russian hard red winters, and some of the better Argentine samples. The remaining samples do not show a very wide differentiation, the shortest time being twenty-one (21) minutes for United States white Club, and the longest seventy-nine (79) minutes for Lab. No. 6 (Argentine). There is a very poor correlation between the results of baking tests (Tables II to VII) and Pelshenke time, although the hard red spring wheats which are of the highest baking quality also gave the longest Pelshenke times. Apart from indicating the superior quality of these wheats, however, the test would appear to be quite unreliable.

PROTEIN

Protein percentage is expressed on a 13.5% moisture basis. The highest protein samples were the United States and Canadian hard red spring wheats, although the lower grades of the latter, particularly from Vancouver, fall into the medium class due partly to the higher percentage of Garnet wheat. The hard red winter, wheats of Russia, United States and Argentine had a medium to moderately high protein content, and the United States hard white wheats were also of medium protein content.

The Australian, Austrian, English, French, German, Italian and Yugo Slavian samples were all low protein wheats. The white Club wheat from the American Pacific coast was somewhat poorer and the United States soft white had an extremely low protein content.

It is interesting to note the spread between protein content of wheat and that of the flour. In the United States hard red spring wheats and in the higher grades of the Canadian, this spread is very small, but in the softer wheats, it is considerable, being usually about 1% to 1.4% and as high as 1.7% in the case of sample No. 44. (In this particular case it should be pointed out that the flour yield is low, owing to the difficulty in cleaning the bran, so it probably represents more of the central portion of the endosperm which is lower in protein content)

DIASTATIC ACTIVITY

In considering the results of diastatic activity determinations, it must be remembered that the wheats were experimentally milled and were accordingly considerably lower in diastatic activity than would be the case if the wheats were milled commercially. The best flours in this respect were those milled from Canadian and United States hard red spring wheats, and the hard red winters of United States, Russia and Hungary and some of the Argentine samples. The higher diastatic activity of the lower grades is very noticeable in the Canadian samples, particularly in the case of the Vancouver averages, grade No. Four Northern from Vancouver having the highest diastatic activity of all the wheats examined. No. One Hard (Winnipeg averages) was the poorest of the spring wheats.

The Australian wheats although rather poor in diastatic activity were the best of the soft wheats. Rather outstanding were the very low figures recorded for the Italian samples, particularly Lab. No.34 which had a diastatic activity of only 46 units. In this instance the flour had a greasy feel which is apparently associated with a high degree of starch resistance. The United States soft winter and white wheats were superior to the Italian samples, and comparable to the other European soft wheats.

CAROTENOID PIGMENTS

The results of the determination of carotenoid pigments call for little comment, but it is interesting to note that the Australian wheats which are credited with being of excellent colour, tend to be a little higher than Canadian wheats in carotenoid pigments. On the whole the Argentine wheats gave flours of lower carotene content than those of the other two large importing countries.

NEW SOUTH WALES SAMPLES

On account of the great differences in grain texture the samples were given different conditioning treatments. Baringa which was extremely hard was brought to 15.5% moisture, Dundee and Pusa 4 to 15%, and Ford, a very soft starchy sample, to 14%. Dundee and Baringa were excellent milling wheats, the former behaving essentially like a Manitoba No. One Northern, but the latter was a little harder. Pusa 4 was of very good milling quality, similar to No. Four Northern, but the final reductions were a little difficult due to a "woolliness" of the stock characteristic of many Australian wheats. Ford although very soft and starchy in appearance, was a good milling wheat yielding much less break flour than one would anticipate. It was very similar to the other Australian F.A.Q. samples in milling quality.

The four varieties gave excellent flour yields, which, when considered in relation to bushel weight, were superior to those obtained from any other wheat tested.

The Pelshenke test would place Pusa 4 at the top of the New South Wales wheats and in the same class as some of the Canadian hard red spring and Russian wheats. Dundee and Ford gave similar times to the better Argentinian wheats. Baringa, although extremely hard, gave a short fermentation time of 35 minutes, which would place it in the weak wheat class.

Pusa 4, Dundee and Baringa had fairly high protein percentages, the protein of the wheat being nearly as great as that of the Canadian hard red spring wheats, but the spread between protein of the wheat and that of the flour was greater than that of the Canadian samples. The protein content of Ford was very similar to that of the United States hard white wheats.

The diastatic activity of the three varieties, Pusa 4, Daringa and Dundee, was considerably higher than the figure one usually associates with Australian wheats, and approached the figures obtained for No. Three and Four Northern from Vancouver. Ford, however, had a very low diastatic activity of 58 units, which is considerably poorer than average Australian. As Australian wheats are known as poor "gassers" the low diastatic activity of Ford is a serious drawback.

Like the other Australian samples tested, Pusa 4, Dundee and Ford were comparatively rich in carotenoid pigments, but Daringa was less strongly pigmented.

RESULTS OF BAKING TESTS

The results of baking tests are given in Tables III to VII. Table VIII shows the means of the loaf volumes given by each flour with all baking procedures. Loaf volumes recorded are the means of duplicate bakings on different days, the difference between duplicates being given in the adjoining column. The standard deviation of the distribution of differences between duplicate determinations is 18.3 ccs., so differences in loaf volume of between 35 and 40 ccs. may be taken as significant.

Water absorption which is on the basis of 13.5% moisture in the flour, is given to the nearest 0.5% and is that quantity of water which yielded a dough of optimum consistency at the time of panning, using the "malt-phosphate" formula. The absorption using other formulas is not given, but in general the "malt-phosphate-bromate" formula required a slight increase and the "high-yeast-high sugar-bromate" formula a decrease of approximately 1%.

On account of the importance attached to the handling properties of the dough, particularly in England where the home grown wheat is notoriously poor as a rule, the degree of excellence of the flour in this respect is given in Table III. Once again, although handling quality of the dough is given only for the "malt-phosphate" formula, it is altered somewhat by the other formulas. Generally bromate resulted in an improvement in handling quality, particularly with the spring wheats, and those which gave a marked positive response to bromate. In many cases the "high yeast high sugar-bromate" formula gave a dough of poorer handling qualities. However the changes in handling quality induced by the different formulas were generally not nearly so great as the differences between flours.

The "response to bromate", "response to mixing", etc., or the change in loaf volume caused by the use of bromate or additional mixing time, are given in Tables IV, V and VII. These responses are of interest but in the light of the recent work of Aitken and Geddes[21] the actual magnitudes should not be compared with each other without considering also the loaf volumes.

The method of judging the loaves baked in this investigation was that of the Associate Committee on Grain Research of the National Research Council of Canada. Grain and texture, crumb colour and symmetry were recorded on a numerical scale, but crust colour was described only. To more fully describe loaf characteristics, key letters were frequently appended to the score.

The system used is as follows:-

Symmetry - Perfect score 5

g = green or under-fermented
o = old or over fermented
r = rough
s = shell top

sl = slightly

Crust Colour

P = pale M.P. = medium pale S = satisfactory
D = darker than ideal

Grain and Texture - perfect score - 10

C = coarse c = close o = open

Crumb colour - perfect score - 10

G = grey Y = yellow

It should be mentioned here that the term baking quality as used in this paper is really meant to convey potential baking strength or potential baking quality. Baking quality is purely a relative term and the baking quality of a flour may be good or bad according to the use to which it is to be put and the baking methods which are used. It is therefore impossible to pass judgment on the baking quality of a flour without first knowing the purpose for which it is intended. However one can with reasonable certainty, by the use of a number of baking procedures, elaborated after much research, measure the "baking potentialities" of one wheat relative to that of another. In the following discussion the wheats studied in this investigation are compared on the basis of their "baking potentiality".

The Canadian and United States hard red spring wheats were the highest quality wheats studied, but grades Nos. Two, Three and Four Northern from Vancouver were greatly inferior to the corresponding Winnipeg "averages" -- a fact which could probably be accounted for by the large proportion of Garnet in the Vancouver samples. These grades had a lower protein content, were higher in diastatic activity than the Winnipeg "averages", and gave loaves of smaller volume, of coarse texture, and dark crust colour. Unlike the Winnipeg averages (all grades) and the No. One Northern from Vancouver, they responded negatively to bromate and "high yeast-high sugar-bromate" formulas producing loaves of an over-fermented appearance.

TABLE III

Results of Baking Test - Malt-Phosphate Formula.

Lab. No.	Water Absorption %	Mean Loaf Vol.	Difference between Duplicates	Texture (10)	Crumb Colour (10)	Crust Colour	Symmetry	Dough handling properties
Argentine								
1	57.5	685	20	8.5	8	MP	4.5	Good
2	55.0	643	5	5.5	5.5	a	3.5	Good
3	52.5	633	35	6	6.5	MP	3 sl.c	Fair
4	51.5	550	10	5.5c	5.5	P	1 rs	Fair but slackens badly
5	51.0	505	0	3.5C	5 g	P	1 gs	Fair
6	54.0	610	0	6	6.5	MP	3	Good
7	54.5	660	0	6	6.5	MP	3	Good
Australia								
8	52.5	533	15	3 C	6	MP	2 rs	Poor, putty like
9	51.5	540	0	3	6	MP	2 gs	" " "
10	51.5	568	25	5	7	MP	2 gsls	" " "
11	50.5	525	30	5	6.5	MP	1.5 g s	" " "
Austria								
12	52.5	600	20	5.5	6	MP	2.5	Fair
Canada								
13	58.5	723	15	5	5.5	MP	4.5 g	Excellent
14	58.5	725	20	5	5.5	S	4.5 g	"
15	58	713	15	4.5	5	S	4.5 g	"
16	58.5	715	0	4 C	4.5	S	4 g	Very good
17	59.0	738	25	4 C	4 g	S	4 g	Very good tendency to slacken
18	59.0	758	5	5	6	S	4.5 slg	Excellent
19	58.5	693	15	4 C	5.5	S	4.5 slg	"
20	59.5	650	20	3 CO	5.5	S	4.5	Very good
21	60.0	655	30	3 C	4.5	S	3	Very good but tendency to slacken.
England								
22	49.5	465	30	2.5C	5.5	P	0.5 r	Extremely poor.
France								
23	47.5	495	0	3 c	5	P	1.5 gs	Poor
24	48.5	500	0	3.5c	5	P	1 cr	"
Germany								
25	48.5	503	5	3.5c	5	P	1.5 gs	Poor (better than Aust.)
26	48.0	483	5	3 c	5	P	1 gs	Poor
Hungary								
27	49.5	593	25	6	6	MP	2.5	Fair
28	50.0	598	25	6	6	S	2.5	Fair

TABLE III (CONT'D)

Lab. No.	Water Absorption %	Mean Loaf Vol.	Difference between Duplicates	Texture (10)	Crumb Colour (10)	Crust Colour	Symmetry	Dough handling properties
Italy								
29	50.5	460	20	1.5c	5 g	P	1 gr	Very poor
30	49.5	463	5	2.5c	5 g	P	1 grs	Poor
31	49.0	450	30	1 c	4 g	P	1 grs	Poor
32	52.5	490	20	3 c	5 g	P	1 gr	Poor
33	50.5	493	5	3.5c	6 g	P	1 grs	Poor
34	50.5	413	25	1 c	2 g brown	P	0 grs	Extremely poor
Russia								
35	55.5	725	30	6.5	7	MP	4	Very good
36	55.5	723	35	6.5	7	MP	4	Very good
United States								
37	56.5	685	20	5	6	S	4 sl g.	Excellent
38	56.5	650	10	5.5	6	S	3.5 g	Excellent
39	51.0	550	10	5.5 c	6	MP	2 g	Fair
40	57.5	780	20	6	6.5	S	5	Excellent
41	57.0	745	10	5.5	6.5	S	5	Excellent
42	49.5	458	5	2.5 C	4	P	1 o	V. Poor
43	51.5	583	5	4 C	5	MP	2.5 g	V. Good
44	52.5	575	5	5 C	5.5	MP	2 g	Good
45	52.0	453	15	2.5 C	4	P	0.5 or	V. Poor
Jugo Slavia								
46	48.5	500	30	1 C	2 g	P	1 ors	V. Poor strong smell of legume.
New South Wales, Australia								
47	56.5	680	0	5.5	5.5	S	4 g	Excellent
48	53.5	565	10	5.5 c	6.5	P	2 o	Very good
49	53.5	575	10	3 C	5.5	D	2.5 g	Fair
50	53.5	630	0	5.5	5.5	S	4 g	Very good but slackens badly at panning time.

TABLE IV

Results of Baking Tests - Malt-Phosphate-Bromate Formula.

Lab. No.	Mean Loaf Volume cc.	Difference between Duplicates	Texture (10)	Crumb Colour (10)	Crust Colour	Symmetry	Response to Bromate ccs.
Argentine							
1	668	5	7	7.5	MP	4 sl o	- 17
2	668	5	6.5	6.5	S	3.5 sl o	25
3	575	30	4.5 C	6	S	1.5 or	- 58
4	570	20	5.5 c	6	MP	2 s	20
5	575	30	6	6	MP	2 rs	70
6	573	5	6	6.5	MP	1.5 or	- 37
7	570	0	4.5	6.5	MP	2 or	- 90
Australia							
8	528	15	4 C	6.5	MP	1.5 or	- 5
9	530	30	4.5	6.5	MP	1.5 or	- 10
10	580	20	6	7	MP	1.5 or	12
11	523	15	5	6.5	MP	1.5 or	- 2
Austria							
12	575	10	6	6	MP	2 sl o	- 25
Canada							
13	875	40	7	6	MP	5	152
14	865	30	7	6	S	5	140
15	868	15	5.5	6	S	5	155
16	795	10	6	6	S	5	80
17	795	40	6	6	S	5	57
18	863	35	6	6.5	S	5	105
19	680	20	4 C	5.5	S	4.5 sl o	- 13
20	623	15	4 C	5	S	3.5 o	- 27
21	595	30	3 CO	4.5 g	S	2.5 or	- 60
England							
22	440	0	2 C	5.5	P	0 or	- 25
France							
23	475	10	3 c	5	P	1 or	- 20
24	470	0	3 c	5	P	0.5 or	- 30
Germany							
25	493	5	4 c	5	P	1 or	- 10
26	483	5	4.5 c	5	P	0.5 or	0
Hungary							
27	583	5	5.5	6	MP	2 o sl r	- 10
28	560	20	5.5	6	MP	1.5 o sl r	- 38

TABLE IV (CONT'D)

Lab. No.	Mean Loaf Volume cc.	Difference between Duplicates	Texture (10)	Crumb Colour (10)	Crust Colour	Symmetry	Response to Bromate
Italy							
29	473	25	3.5 o	6 g	P	1 rs	13
30	465	5	3.5 o	6 g	P	1 rs	2
31	475	30	3.5 o	5 g	P	1 rs	25
32	478	15	3.5 o	5 g	P	1 rs	- 12
33	485	20	3.5 o	6 g	P	1 rs	- 8
34	400	20	1 o	2 g	P	0 rs	- 13
Russia							
35	675	10	7	7.5	MP	3.5 sl o	- 50
36	675	30	7	7.5	MD	3.5 sl o	- 52
United States							
37	753	15	6	6	S	4.5	68
38	753	35	7	6.5	S	5	103
39	610	10	6.5	6.5	MP	2.5 s	60
40	815	10	7	6.5	S	4.5 sl o	35
41	728	5	6.5	6.5	S	4 or	- 17
42	418	5	1.5 C	3.5	P	0 or	- 40
43	650	0	7	6	MP	3.5	67
44	648	15	6.5	6.5	MP	3 sl o	73
45	448	5	2 C	4	P	0.5 or	- 5
Yugo Slavia							
46	483	5	2 C	2 g	P	0.5 or	- 17
New South Wales, Australia							
47	768	5	7.5	7	S	4.5 sl o	88
48	533	15	4 C	5.5	P	2 o	- 32
49	718	25	6	7	D	4.0	143
50	645	10	6.5	6.5	S	3.5 sl o	15

TABLE V

Results of Baking Tests - High yeast-High Sugar-Bromate Formula

Lab. No.	Mean Loaf Volume cc.	Difference between Duplicates	Texture (10)	Crumb Colour (10)	Crust Colour	Symmetry	Response (basis malt phosphate)
Argentine							
1	575	30	6.5	7	MP	3.5 sl o	- 110
2	613	25	6.5	6.5	MP	2.5 sl o	- 30
3	540	0	4	6	MP	1 or	- 93
4	575	10	6 c	5.5	MP	1.5 s	25
5	560	20	6	6	MP	1.5 s	55
6	528	5	5.5	6.5	MP	1.5 or	- 82
7	568	5	4.5	6.5	MP	1.5 or	- 92
Australia							
8	503	25	3 C	6	MP	1 or	- 30
9	530	20	4.5	6.5	MP	1 or	- 10
10	565	10	6	6.5	MP	1.5 or	- 3
11	530	20	5 C	6.5	MP	1.5 ors	5
Austria							
12	555	10	4 C	6	MP	1.5 or	- 45
Canada							
13	760	20	8	6.5	S	4.5 sl o	37
14	800	30	8	6	S	4.5 o	75
15	795	20	6.5	6	S	4.5 o	82
16	725	30	7	5.5	S	4 o	10
17	670	0	5.5 C	4.5	S	4 s	- 68
18	788	25	6	6.5	S	4 sl o	30
19	610	0	3 C	5	S	3 o	- 83
20	555	10	3 C	5	S	2.5 or	- 95
21	535	10	3 C	5	S	1.5 or	- 120
England							
22	470	0	2 C	6	P	0.5 or	5
France							
23	508	5	3 c	5	P	0.5 or	33
24	473	5	3.5 c	5	P	0.5 or	- 27
Germany							
25	510	10	3.5 c	5	P	0.5 or	7
26	485	30	3 c	5	P	0.5 or	2
Hungary							
27	555	10	5.5	5	MP	1 or	- 38
28	550	20	5.5	6	MP	0.5 or	- 48

TABLE V (CONT'D)

Lab. No.	Mean Loaf Volume cc.	Difference between Duplicates	Texture (10)	Crumb Colour (10)	Crust Colour	Symmetry	Response (basic salt phosphate)
Italy							
29	548	15	4 c	6 g	P	1 or	88
30	490	0	1.5 c	5 g	P	1 or	27
31	570	0	4 c	5 g	P	1 or	120
32	498	35	4 c	5 g	P	1 or	8
33	480	20	4 c	5 g	P	1 or	- 13
34	468	35	3 c	4 g	P	0 rs	55
Russia							
35	578	15	7	7.5	MP	2.5 o	-147
36	595	20	7	7	MP	2.5 o	-128
United States							
37	640	20	5.5 c	6	S	2 or	- 45
38	698	5	6.5	6.5	S	4.5	48
39	605	20	6.5	6.5	MP	2 or	55
40	738	5	7	6.5	S	4.5 sl o	8
41	685	20	7	6.5	S	3.5 o	- 60
42	463	5	1.5 C	3.5	P	0 or	5
43	705	5	6.5	6	S	3 sl o	122
44	680	10	7	6.5	MP	2.5 or	105
45	480	0	2 C	4	MP	0 or	27
Yugoslavia							
46	515	20	3 Cc	2 g	P	0.5 or	15
New South Wales, Australia							
47	678	25	6	7	S	3.5 o	- 2
48	603	5	5.5	6.5	P	2 o	38
49	680	0	5.5	6.5	D	3 or	105
50	625	20	5.5	6.5	S	2.5 os	- 5

TABLE VI

Results of Baking Tests - Malt-Phosphate-Bromate Formula
1 min. Hobart-Swanson

Lab. No.	Mean Loaf Volume cc.	Difference between Duplicates	Texture (10)	Crumb Colour (10)	Crust Colour	Symmetry
Argentine						
1	655	10	7.5	7	MP	3.5 sl o
2	665	10	6.5	6.5	MP	3.5 sl o
3	575	30	4 c	6.5	MP	1 or
4	580	20	6	6	MP	1 or
5	583	5	6 c	5.5	MP	2 rs
6	565	20	5.5	6.5	MP	1 or
7	565	10	5.5	6.5	MP	1.5 or
Australia						
8	525	25	5 c	6	MP	1 or
9	545	10	4 c	6	MP	1.5 or
10	593	25	6.5	7	MP	1.5 or
11	535	20	4 c	6.5	MP	1 or
Austria						
12	595	10	6	6	MP	1.5 or
Canada						
13	928	15	6	6.5	S	5
14	895	30	6	6	S	5
15	918	15	6	6	S	5
16	803	25	6	6	S	5
17	790	0	6	5.5	S	4.5 sl o
18	890	10	6	6.5	S	5
19	713	5	5	6.5	S	4.5
20	630	20	4 c	5	S	3.5 o
21	600	20	3 c	5	S	2.5 or
England						
22	453	5	2 c	4	P	0.5 or
France						
23	473	15	4.5 c	5	P	1 os
24	475	30	3.5 c	5	P	0.5 or
Germany						
25	510	20	3.5 c	5	P	1 sl or
26	488	15	3.5 c	5	P	1 sl or
Hungary						
27	588	25	5.5	5	MP	1.5 sl or
28	555	20	6	6	MP	1.5 sl or

TABLE VI (CONT'D)

Lab. No.	Mean Loaf Volume cc.	Difference between Duplicates	Texture (10)	Crumb Colour (10)	Crust Colour	Symmetry
Italy						
29	500	20	5 c	5.5 g	P	1 rs
30	435	20	3 c	6 g	P	1 r
31	475	30	4 c	5 g	P	1 rs
32	520	20	5 c	5.5 g	P	1 rs
33	483	15	5 c	6 g	P	1 rs
34	405	10	3 c	2 g	P	1 rs
Russia						
35	703	5	7.5	7.5	MP	3 o
36	683	25	7.5	7.5	MP	3 o
United States						
37	755	10	8	6.5	S	5
38	743	25	7	6.5	S	5
39	608	15	6.5	6.5	MP	3 s
40	823	5	7	6.5	S	4.5 sl o
41	708	15	7	6.5	S	4 o
42	418	15	2 C	3.5	P	0 or
43	655	0	7	6	MP	3.5
44	640	0	6	6.5	MP	3
45	455	10	3 C	4	P	0 or
Yugoslavia						
46	518	25	2 C	2 g	P	0.5 or
New South Wales, Australia						
47	788	25	7.5	7.5	S	4.5 sl o
48	540	0	4.5	6.5	P	2 o
49	723	25	6	7	D	4
50	675	10	6.5	7	S	3.5 sl o

TABLE VII.

Results of Baking Tests - Malt-Phosphate-Bromate Formula
3 mins. mix - Hobart-Swanson

Lab. No.	Mean Loaf Volume cc.	Difference between Duplicates	Texture (10)	Crumb Colour (10)	Crust Colour	Symmetry	Response to Mixing
Argentine							
1	640	10	8	7.5	MP	3.5 o	- 15
2	635	30	5 C	6.5	MP	3 sl or	- 30
3	513	25	3 C	6	MP	0.5 or	- 62
4	510	20	4 C	5.5	MP	1 or	- 70
5	515	30	6	5.5	MP	1 or	- 68
6	510	20	2.5 C	6.5	MP	1 or	- 55
7	525	10	5 C	6	MP	1 or	- 40
Australia							
8	483	15	3 C	6	MP	0.5 or	- 42
9	493	5	2 C	6	MP	1 or	- 52
10	545	20	6	7	MP	1.5 or	- 48
11	478	15	2 C	5.5 g	P	0.5 or	- 57
Austria							
12	545	30	5.5	6.5	MP	1.5 or	- 50
Canada							
13	930	0	6	6.5	S	5	2
14	900	30	6.5	6	S	5	5
15	908	25	6.5	6.5	S	5	- 10
16	778	25	6	6	S	4.5 o	- 25
17	730	20	6	5	S	4.5 o	- 60
18	943	25	7	7	S	5	53
19	708	5	5.5	6.5	S	3.5 o	- 5
20	628	5	4.5 C	5.5	S	2.5 o	- 2
21	585	10	4 C	5.5	S	1.5 or	- 15
England							
22	425	0	1.5 C	4 g	P	0 or	- 28
France							
23	460	0	4 C	5	P	0.5 or	- 13
24	458	5	3.5 C	5	P	0.5 or	- 17
Germany							
25	488	5	3 o	5	P	0.5 or	- 22
26	488	15	3 o	5	P	0.5 or	0
Hungary							
27	558	15	5.5	5	MP	1.5 or	- 30
28	493	25	4	6	MP	1 or	- 62

TABLE VII (CONT'D)

Lab. No.	Mean Loaf Volume cc.	Difference between Duplicates	Texture (10)	Crumb Colour (10)	Crust Colour	Symmetry	Response to Mixing
Italy							
29	470	0	5.5 c	5.5 g	P	1 or	- 30
30	448	5	4 c	5.5 g	P	1 or	13
31	460	10	4.5 c	5.5 g	P	1 or	- 15
32	480	0	5 c	6 g	P	1 or	- 40
33	470	20	5.5 c	6 g	P	1 or	- 13
34	393	5	2 c	2 g	P	0 or	- 12
Russia							
35	705	10	7.5	7.5	MP	2.5 sl or	2
36	720	20	7.5	7.5	MP	2.5 sl or	37
United States							
37	705	30	6.5	6	S	3.5 o	- 50
38	698	5	6.5	6.5	S	3 o	- 45
39	605	0	6	6.5	MP	2.5 rs	- 3
40	915	30	7	6.5	S	4.5 sl o	92
41	728	5	6.5	6.5	S	3.5 o	20
42	408	5	2 C	3 g	P	0 or	- 10
43	583	5	6.5 c	6	MP	2.5 o	- 72
44	578	15	5.5 c	5.5	MP	2.5 o	- 62
45	465	30	2 C	4	P	0 or	10
Yugoslavia							
46	503	5	3 C	1 g	P	0.5 or	- 15
New South Wales, Australia							
47	835	0	8	7.5	S	4.5 sl.o	47
48	535	20	4	6.5	P	1 or	- 5
49	673	5	6	7	D	4	- 50
50	630	0	5	6.5	S	3 o	- 45

TABLE VIII

Mean Loaf Volume - All Baking Tests

Lab. No.	Mean Loaf Volume
Argentine	
1	645
2	645
3	567
4	557
5	548
6	557
7	578
Australia	
8	514
9	528
10	570
11	518
Austria	
12	574
Canada	
13	843
14	837
15	840
16	763
17	745
18	848
19	681
20	617
21	594
England	
22	451
France	
23	482
24	475
Germany	
25	501
26	485
Hungary	
27	575
28	551
Italy	
29	490
30	460
31	486
32	493
33	482
34	416
Russia	
35	677
36	679
United States	
37	708
38	708
39	596
40	824
41	719
42	433
43	636
44	624
45	460
Yugoslavia	
46	504
New South Wales, Australia	
47	750
48	555
49	674
50	641

In the response to increased mixing time this difference was not so apparent; all possessed a fair degree of resistance and the Vancouver No. One Northern showed a large positive response. The handling quality of the Canadian flours was very good to excellent, but the No. Four Northern grades showed a tendency to slacken at the time of panning.

The United States hard red spring samples were very similar to the Canadian. Sample No. 40 (No. 1 Dark Northern Spring) was fully equal to Canadian No. One Northern but sample No. 41, which was 1.9% lower in protein content, was similar to Nos. Three and Four Northern. Unlike the Winnipeg averages they did not give such a marked response to bromate, but produced larger loaves by the "malt-phosphate" procedure without the obvious under fermented characteristics. Both gave very good responses to over-mixing however.

Very nearly equal to the poorer United States hard red spring were the Kansas hard red winters. The handling quality of the dough and the symmetry and crust colour of the loaves were excellent, and by the "malt-phosphate-bromate" test they gave loaves equally as good in texture and crumb colour, though smaller in volume, as the best Canadian wheats. Both samples gave a marked positive response to bromate, but were sensitive to over-mixing. The Russian hard red winters, which were otherwise similar to the Kansas wheats, responded negatively to bromate, but were quite tolerant of over-mixing. The handling quality of the Russian samples was not quite so good and both gave loaves with slightly pale crust. In texture and crumb colour they were very good.

The Argentine samples, which represented the main export types, showed quite wide differences. The best samples were one from Buenos Aires and a Bahia Blanca-Barletta and/or Russo. Apart from these two they were no better if as good as the United States soft red winter wheat. Only one Argentine wheat (Lab. No. 5) gave a marked positive response to bromate, the others showing either very little effect or a high negative response. There was a tendency for the flours to be fully matured when freshly milled, giving loaves of mature appearance or even slightly over-fermented with the "malt-phosphate" formula. Lab. Nos. 4 and 5 (upriver wheats) were exceptions, both giving rather green loaves. Both were also inferior to the other Argentine wheats in handling quality in spite of the fact that they were the highest protein samples. They gave loaves of poor appearance with a tendency to shell-top, and rather coarse and close crumb texture. All the Argentine samples responded negatively to over-mixing but Lab. No. 1 was damaged least by this treatment.

Characteristic of the Australian samples were the inelastic, short, putty-like doughs, of poor handling quality. In spite of this disability, however, the baking quality was moderately good, one sample (No. 10) from South Australia being equally as good as the Hungarian samples which were of much better handling quality. The other three Australian samples were similar to each other but inferior to sample No. 10. All gave loaves of rather poor external appearance and pale crust, but fairly good crumb colour. With the exception of Lab. No. 10, the crumb texture was rather coarse. They showed very little response to bromate and responded negatively to over-mixing.

The Hungarian and Austrian wheats were very similar to the South Australian sample, but were superior in handling quality. They were of better baking quality than the other three Australian wheats examined.

The English, French, German, Italian, United States soft white and White Club, and Uygo-Slavian wheats, were all of poor baking quality. The handling quality of the dough in all cases was poor or very poor, although it was noted that the German wheats, which were perhaps if anything a little better than the others, produced better feeling, more elastic doughs than the Australian samples.

All the low quality wheats producing loaves of small volume were relatively unaffected by the addition of bromate; in most cases the responses were not significant. The responses to increased mixing time were negative but also of a small order. These results bear out the contention of Aitken and Geddes[21] that weak flours giving loaves of small volume are less sensitive to increasing severity of treatment than are stronger flours. In cases where the loaves baked by the malt-phosphate formula were "green", bromate generally resulted in an improvement in texture of crumb, but when a flour gave a mature loaf by the former test, bromate had the opposite effect.

The wheats of poorest baking quality were the English, Italian (Lab. No. 34) and the United States soft white and White Club. (It should be remembered of course that the two latter types are not intended for bread making purposes). It was difficult to understand the reason for the poor baking quality of the Italian sample (No. 34) which had a fairly good protein content, but it was noticed that the handling quality of the dough was at least fair until after the second punch when it became extremely poor, and very slack and sticky; at this stage gas production appeared to have ceased entirely. This flour was of a greasy texture, of very low diastatic activity and high carotene content, so it would appear that even with the diastatic supplement used, gas production ceased before panning time, probably due not so much to lack of diastase as to a high degree of starch resistance. A peculiarity of the Italian samples not shared by the other weak wheats was the increase in loaf volume resulting from the "high yeast-high sugar-bromate" test.

BAKING QUALITY OF NEW SOUTH WALES WHEATS

Pusa 4 was of excellent baking quality, and although it did not give such large loaves as the higher grade Manitoba wheats tested, the bread was superior in crumb colour and texture. For a wheat of such high quality the water absorption (56.5%) was rather low but the handling quality of the dough was excellent. The large positive responses to bromate and increased mixing time indicate its ability to withstand severe baking conditions.

In Plate 1, bread baked from Pusa 4 is compared with that baked from Australian F.A.Q. and an average Manitoba No. One Northern. The baking method used was the "malt-phosphate-bromate" procedure with the Hobart mixer. The average No. One Northern chosen was not equal in baking quality to the samples included in this investigation (flour of which was not available) but nevertheless it was a fair average sample. Although not giving a significantly larger loaf than Pusa 4 it had a higher water absorption, and the dough was superior in handling quality. The inferior quality of average Australian as compared with Pusa 4 is obvious and need not be enlarged upon. Taking everything into consideration, Pusa 4 must be classed as equal in baking quality to the average Manitoba One Northern.

Dundee, a recent introduction in New South Wales, was also of much better baking quality than average Australian, although inferior to Pusa 4. It fell in the same class as the United States hard white wheats, but gave loaves of better crust colour and symmetry. The water absorption was low, but better than that of the United States hard whites. The response to bromate was very small and it gave a negative response to over-mixing. The dough was of very good handling quality.

Baringa and Ford deserve special comment. Whereas in general, loaf volume, particularly over a series of baking tests, is a good indication of baking quality, this is not always the case. In the instance of these


MANITOBA NO.1 NORTHERN
LOAF VOLUME 795 cc.
PUSA 4
LOAF VOLUME 768 cc.
AUSTRALIAN F.A.Q.
LOAF VOLUME 578 cc.

Plate I.

two varieties, their inherent characteristics are such that a consideration of loaf volume only would lead to erroneous conclusions.

In loaf volume, Ford was very little different to Australian F.A.Q., and the loaf characteristics were if anything inferior, but the handling quality of the dough was much better than average Australian. For its ability to impart an improved handling quality to a blend, it is in considerable demand by millers, and is credited with being of superior quality to ordinary Australian wheat. Yet a baking test would class it as a wheat of poor baking quality.

As it was possible that the poor loaf volume might be due to its lack of diastatic activity which the addition of 0.3% of diastatic malt failed to adequately supplement, baking tests using 0.6% of malt were used. This additional quantity, however, failed to show any change in loaf volume so it was concluded that a high degree of starch resistance rendered the addition of a diastatic supplement almost valueless.

The responses to bromate and over-mixing were negative but there was a large positive response to the "high yeast-high sugar-bromate" formula, which would indicate that the reason for its poor baking quality is a lack of gassing power which cannot be supplemented by ordinary means.

The dough handled very well at the time of mixing and at the first punch, but at the second punch it became tough with a tendency to shortness. At panning time this tendency increased and it was found difficult to seal the dough. Proofing was slow, and the loaves had an aged appearance.

The dough handling characteristics of Baringa were entirely opposite to those of Ford. Unless a very tight dough was made it was sticky, and handling became increasingly difficult as fermentation proceeded, until at panning time it was quite "runny" and difficult to mould.

In spite of this fact, loaf volume measurements would indicate that Baringa was at least as good as the Russian and best Argentine samples, but as it could not be handled under commercial conditions, it cannot be classed as the equal of these wheats.

The response to bromate was excellent, but as would be expected from the nature of the dough, the response to over mixing was negative.

The peculiar behaviour of these two varieties and the impossibility of satisfactorily classifying them on a basis of flour strength suggested that some information might be gained by baking a blend of both flours. The results are given in Table IX and illustrated in Plate 2.

TABLE IX

Flour	Loaf Volume ∅	Texture	Crumb Colour	Crust Colour	Symmetry
Baringa	718	6	7	D	4
Ford	533	4 C	5.5	P	2 o
50% Baringa 50% Ford	710	7	7	S	4

∅ Baking Procedure - "malt-phosphate-bromate" 3 min. Hobart. mixer.

The results are particularly interesting. The blended flour gave a loaf equal in volume and crumb colour to Baringa and of better texture than either component of the blend. The crust colour was satisfactory whereas that of Baringa was much too dark, and that of Ford very pale. More important perhaps was the handling quality of the dough which was as good as a Manitoba No. Four Northern, and without the disadvantages of either component baked separately.

In view of the above results it seems illogical to judge Ford purely on a basis of loaf volume, placing it in the same class as average Australian, as it apparently has the capacity of imparting valuable characteristics to a blend. Similarly loaf volume measurements alone would not adequately describe Baringa.

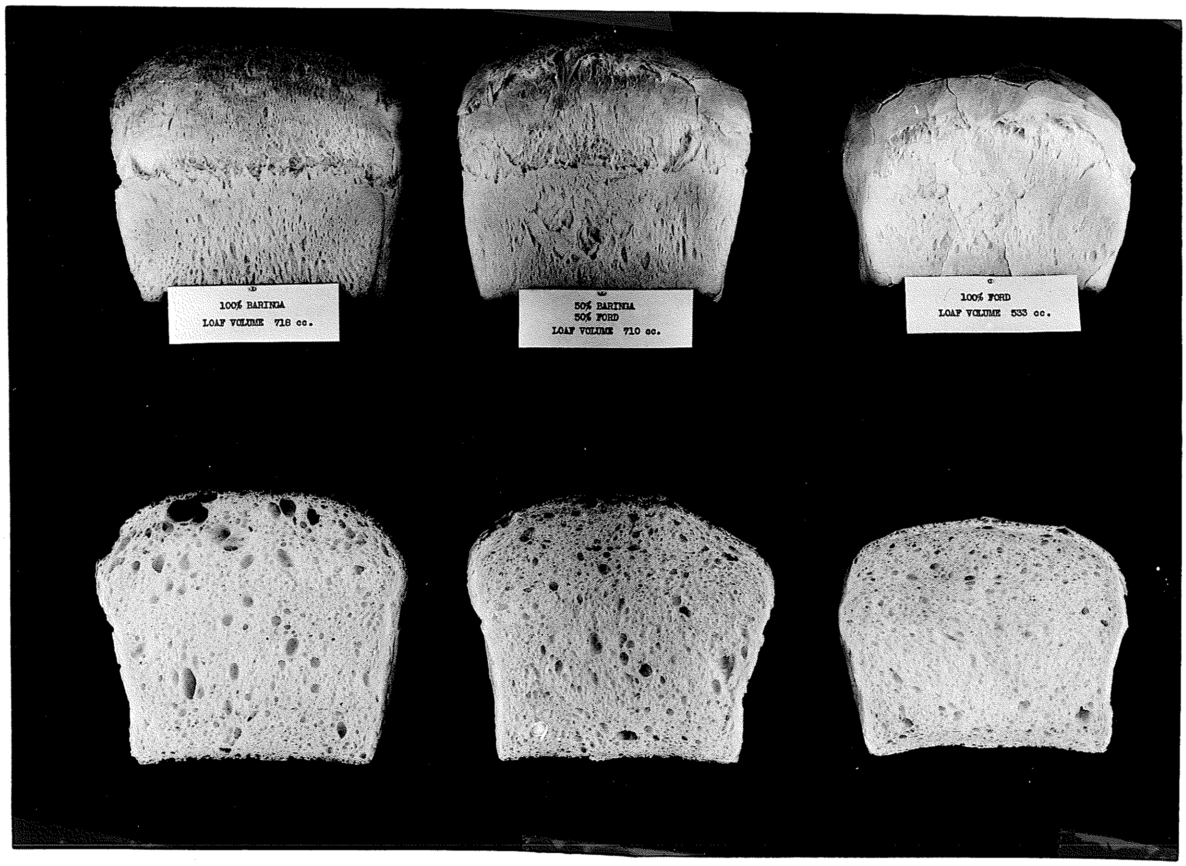

100% BARINGA
LOAF VOLUME 718 cc.
50% BARINGA
50% FORD
LOAF VOLUME 710 cc.
100% FORD
LOAF VOLUME 533 cc.

Plate 2.

In Table X the wheats tested are arranged in descending order of loaf volume as determined by four different baking procedures and by the mean volume of all five tests. As a difference in loaf volume of less than 35 ccs. is not significant, classes extending over a total range from 365 ccs. to 950 ccs. have been arbitrarily chosen, each extending over a range of 35 ccs. with one exception, a class extendinf from 890 to 950 ccs.

The maximum range in loaf volume for any one baking procedure (537 ccs.) was given by the "malt-phosphate-bromate" baking formula with 3 minutes mix on the Hobart-Swanson machine. This procedure has been found by the Dominion Grain Research Laboratory also to give the greatest range in loaf volume.

The "malt-phosphate-bromate" formula with a three minute mixing time in the Hobart two hook machine gave a range in loaf volume of 475 ccs., but the range using the "malt-phosphate" and "high yeast-high sugar-bromate" procedures (367 ccs. and 332 ccs. respectively) was much smaller. Taking an average of all baking tests the range in loaf volume was 432 ccs.

The "malt-phosphate" test was unsatisfactory by itself in that it often gave "green" loaves and furthermore there was insufficient differentiation within the strong flour class. All the hard red springs but two of the lowest grades from Vancouver, the United States and Russian hard red winters, and one Argentine sample, were all placed closely together in three classes, whereas by the "malt-phosphate-bromate" procedure these same wheats were spread over eight classes. However, the "malt-phosphate" procedure gave a better differentiation within the weaker classes.

The "malt-phosphate-bromate" procedures with the Hobart mixer and the Hobart-Swanson mixer (3 minutes mix) appeared to be very satisfactory the placings being very similar in both cases, although the latter procedure magnified the differences somewhat particularly in the upper classes.

TABLE X

Arrangement of World Wheats in Descending Order of Baking Quality as Determined by Loaf Volume given by Different Baking Methods and by the Average of all Five Methods.

Loaf Volume	Malt-Phosphate Range = 367	Malt-phosphate bromate - Range = 475	X High yeast high sugar bromate Range = 332	∅ Malt-phosphate bromate Range = 537	All tests Range = 43
890-950				13,14,15,18,40	
855-890		13,14,15,18			
820-855				47	13,14,15,18 40.
785-820		16,17,40	14,15,18,40		
750-785	18,40	37,38,47	13	16	16
715-750	13,14,16,17, 35,36,41	41,49	16	17,41	17,41,47 19
680-715	1,15,19,37	19	38,41,43,44	19,35,36,37,38	19,37,38
645-680	7,20,21,38 47	1,2,35,36, 43,44	17,47,49	49	1,2,35,36 49
610-645	2,3,6,50	20,39,50	2,19,37,50	1,2,20,50	20,43,44,50
575-610	12,27,28,43, 44	3,5,10,12,21 27	1,4,35,36, 39,48	21,39,43,44	7,21,39.
540-575	4,9,10,39 49,48	4,6,7,28	3,5,7,10, 12,20,27,28, 29,31	10,12,27	3,4,5,6, 10,12,27 28,48
505-540	5,8,11	8,9,11,48	6,9,11,21, 23,25,46	3,4,5,6,7,48	8,9,11
470-505	23,24,25,26, 32,33,46	23,24,25,26, 29,31,32,33 46	8,22,24,26 30,31,33,45	8,9,11,25,26 28,29,32,33,46	23,24,25, 26,29,31 32,33,46.
435-470	22,29,30,31, 42,45	22,30,45	34,42	23,24,30,31,45	22,30,45
400-435	34	34,42		22,42	34,42
365-400				34	

X Three minute mix, second speed. Hobart two hook dough mixer

∅ Three minute mix -- Hobart-Swanson mixer.

Using an average of all baking tests, the placings were almost identical with those given by the "malt-phosphate-bromate" procedure (Hobart mixer) only. This finding corroborates recent work carried out by the Dominion Grain Research Laboratory using other material.

The "high yeast-high sugar-bromate" procedure was rather disappointing as it failed to give either the range or differentiation between flours given by the "malt-phosphate-bromate" procedures.

The comparison of the efficiency of the various baking procedures used brings out an important point. If through lack of material or time it is inconvenient to use more than one baking test when studying unknown flours a formula including both a malt-supplement and a chemical improver, preferably bromate, should be used. Although by this means one will not be supplied with full information concerning all the peculiarities of each sample, one may be reasonably certain that the placing of the flours on a scale of loaf volume will not be very different to that which would be obtained using a number of baking procedures. The coefficient of correlation between flour protein and malt-phosphate-bromate loaf volume (Hobart Mixer) is 0.8653 (r at 1% point = .37).

On the basis of baking tests only the world wheats examined would be classed as follows:

1. Canadian and United States hard red spring.
2. United States hard red winter.
3. Russian hard red winter and the best Argentinian wheats.
4. United States hard white
5. United States soft red winter, Argentinian, Hungarian.
6. Australian.
7. French, German, Italian.
8. English, United States soft white and white club.

Pusa 4 would fall into Class 1. Dundee into Class 4, and if a blend of Baringa and Ford were considered instead of taking each seperately, it would fall into Class 3.

Farinograph Data

Physical means of dough testing, always popular in Europe, have made considerable headway in recent years, and the introduction of the Farinograph, which is undoubtedly the best machine available for carrying out tests of dough quality, has given an added impetus to this line of investigation. It is claimed for this machine that it makes baking tests almost unnecessary, by supplying all the information required concerning a flour.

In using the Farinograph, doughs may be made with all ingredients, with salt, or plain with water only. For the ordinary mixing curves, the plain flour water dough appears to be the most satisfactory, as the work is thus expedited considerably and the interpretation of results is simplified. In this investigation the latter type of dough has been used. Three hundred (300) grams of flour are placed in the bowl, and sufficient water added to give a point of maximum consistency between 550 and 600 units, or as close as possible to this range.

Interpretation of Farinograph Data

The interpretation of the curves is often very difficult but there are certain characteristics about them which give considerable information concerning the properties of the dough. They are as follows:

(1) The time taken to reach maximum consistency. This appears to be closely related to protein content, the higher protein flours requiring a considerably longer period than low protein flours. In this respect the club wheats are very characteristic reaching the point of maximum consistency almost immediately, certainly long before the ingredients are thoroughly mixed, and thereafter falling off in consistency very rapidly.

(2) The time for which the curve is maintained at or near the point of maximum consistency. The better the quality of the protein in the complex, the greater is this time and the more "stable" the curve. The most stable curves are given by the high quality spring wheat flours.

(3) The rate of falling off in consistency or of increase in mobility. A rapid fall in consistency will indicate a decided tendency for the dough to become slack and sticky during mixing.

(4) The "breaking point," or that point at which suddenly the colloidal nature of the dough changes, and its capacity for holding water is decreased. This is generally indicated by a change in the direction of the curve due to the tendency for the suddenly sticky dough to adhere to the sides of the bowl, increasing momentarily the force necessary to turn the mixer arms. At this point the dough is irretrievably damaged, so it indicates the upper limit of mixing time which the dough will stand. It is not always clearly marked, in some cases the stickiness appearing gradually.

After considerably experience with the Farinograph, the author is confident that the information which it gives can only be applied to the study of the behavior of a dough during the mixing period.

Discussion of the Results of Farinograph Tests

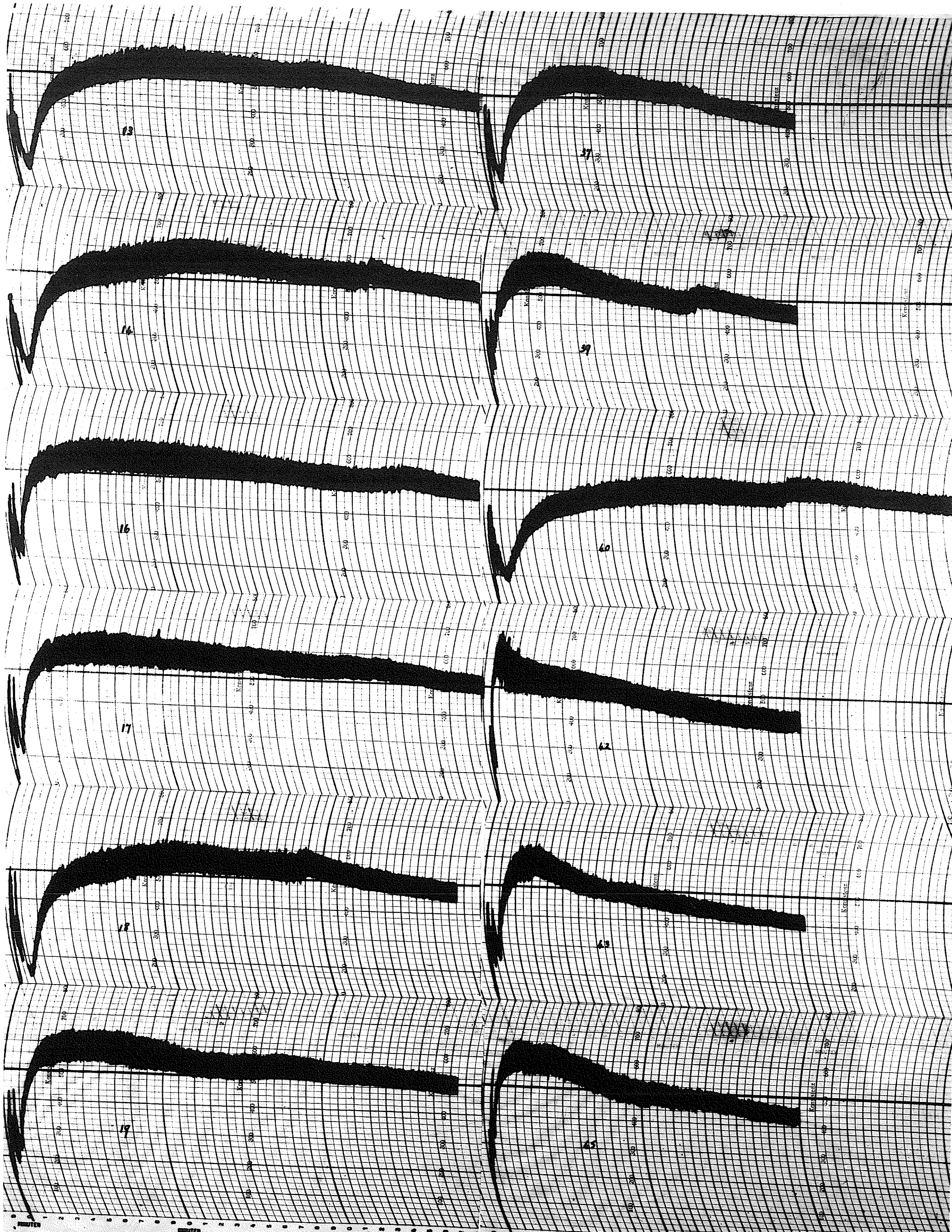
The Farinograph curves of a number of the samples investigated are shown in Plates 3, 4 and 5.

The quantity of water added to 300 grams of flour to make a dough of the necessary consistency has not been given as the writer believes it to be of little value. In spite of all claims to the contrary, the water absorption as determined by the Farinograph is not necessarily a guide to the quantity of water which should be used to obtain a dough of correct consistency for baking purposes. It should be remembered that comparatively few doughs remain at a uniform consistency throughout fermentation. Baringa was an example of a flour which has to be mixed into a very tight dough to avoid stickiness, and even then at the time of panning it becomes exceedingly slack, sticky, and difficult to handle. When baking this flour it was found impossible to handle it if more than 53.5 per cent of water was added, yet on the basis of Farinograph results the absorption was 62.5! Again in the case of flours which tighten during fermentation, the Farinograph indicates a lower water absorption than is found necessary in practice.

With the exception of Pusa 4 (lab No. 47) the best and most stable curves were given by the higher grade Canadian and United States hard red spring wheats. Canadian grades No. 1 Hard, No. 1 and 2 Northern from Winnipeg, and 1 Northern from Vancouver (lab Nos. 13, 14, 15, and 18 respectively) were very similar. A time of approximately ten minutes was rerequired to reach the point of maximum consistency, and thereafter the curves were relatively stable, the "breaking point" coming after eighteen minutes with samples 13, 14, and 18, and after twenty-three minutes with sample No. 15. The United States Dark Northern Spring (lab No. 40) was very similar to the above Canadian samples but was a little more stable, taking two minutes longer to reach the point of maximum consistency. The "breaking point" came after nineteen minutes.

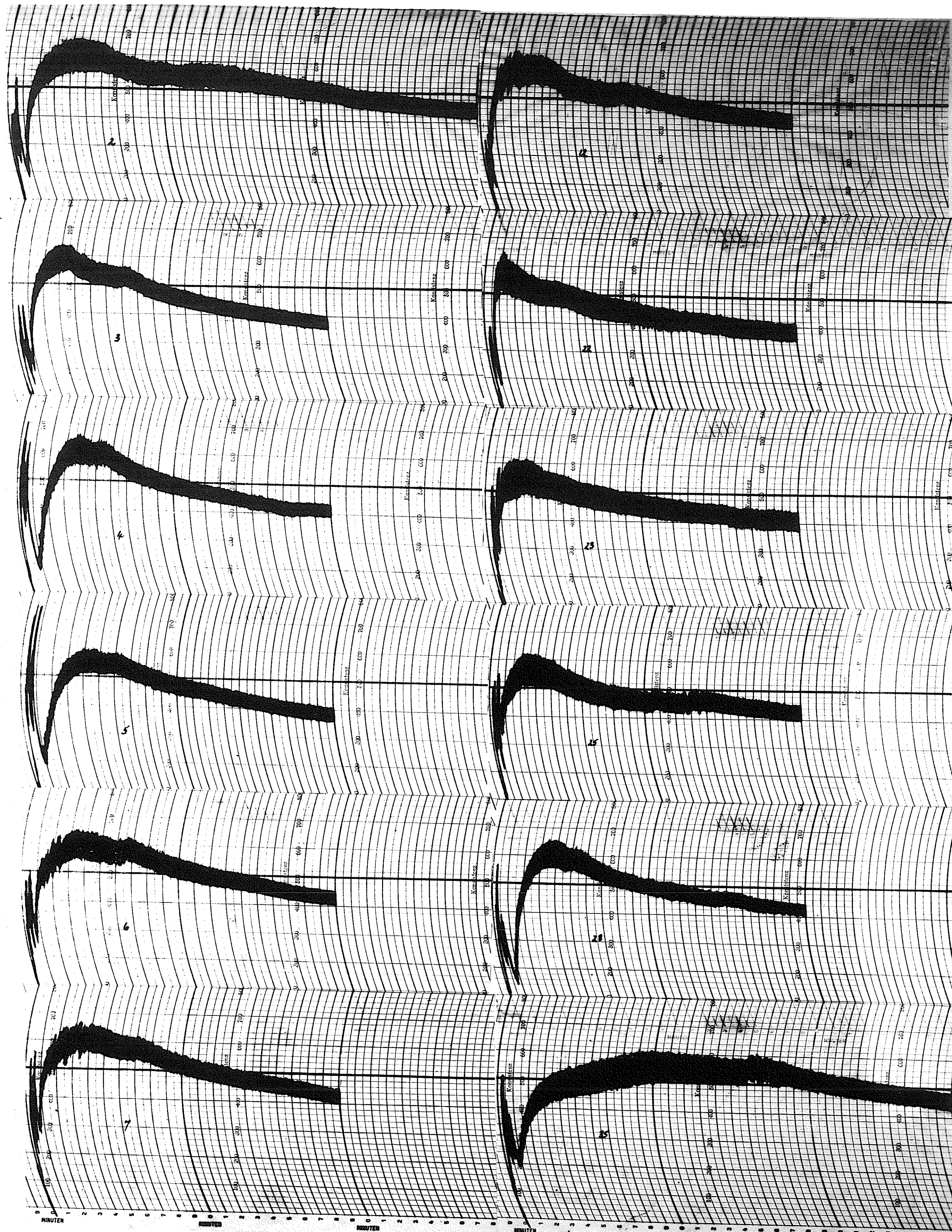
The Russian hard red winter wheats (curve 35) showed surprisingly good results. The development period was long, and the curve remained stable until the "breaking point" after sixteen minutes.

It is noteworthy that all the above samples which have given good Farinograph curves were those which responded well to an increase in mixing time,



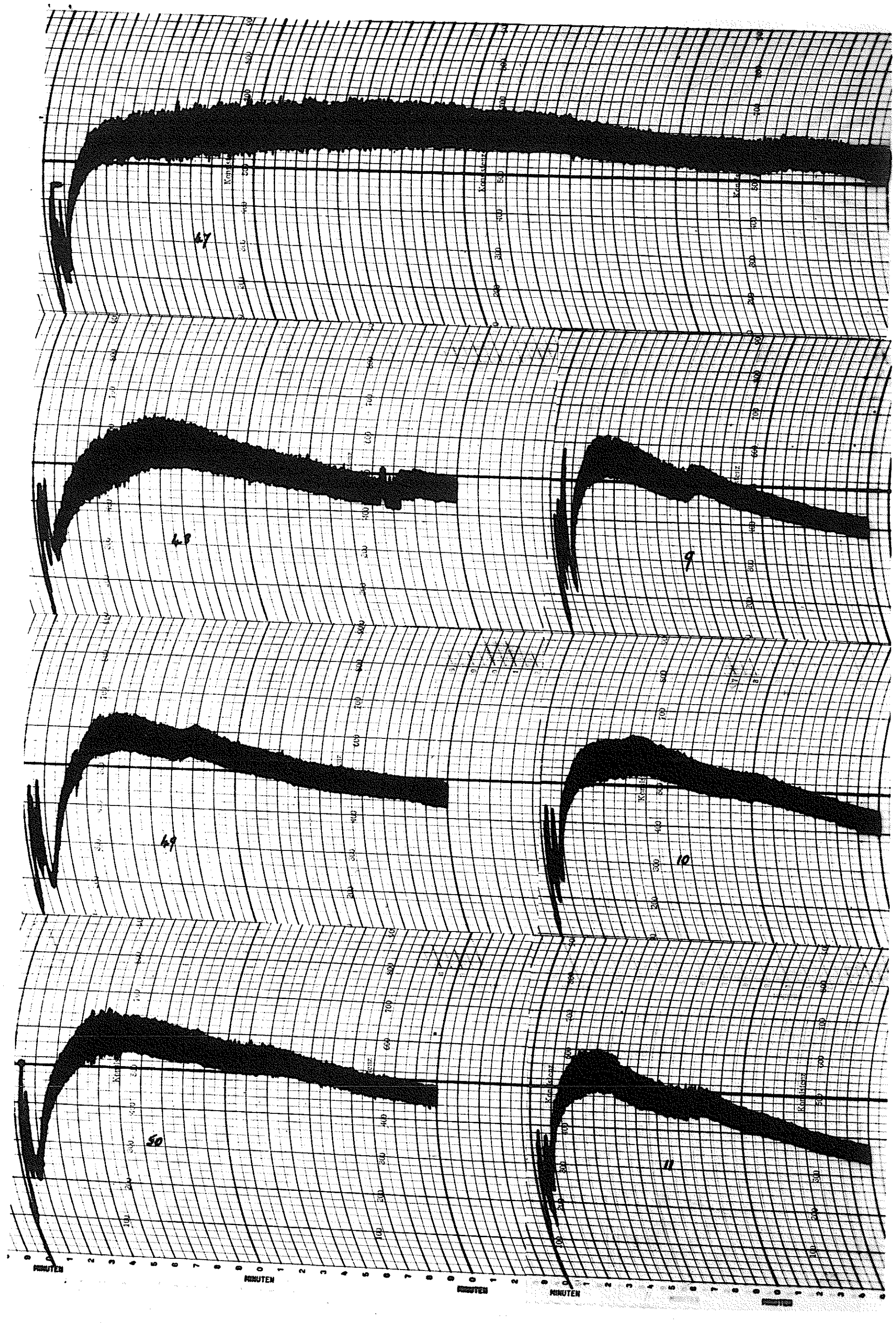
Canadian and United States Samples

Plate 3



Argentinian and European samples

Plate 4



Australian samples

Plate 5

as determined by the baking test. In the case of the European samples the only wheats to respond positively to increased mixing were the Russian samples (with the exception of one Italian sample of which insufficient material was available for Farinograph tests), the others all giving typically weak, unstable curves.

The lower grade Canadian samples which responded negatively to increased mixing time gave much lower curves than the higher grades. There was a tendency for a much more rapid development and less stability with a more rapid onset of stickiness.

All the Argentinian samples (there was insufficient material of lab No. 1 for Farinograph data) gave weak curves, the "breaking point" occurring after five to seven minutes. The poorest curves were given by lab No. 3, 4, and 5 which gave also the greatest negative responses to increased mixing. Lab No. 2, which was least damaged by increased mixing, gave the best Farinograph curve.

Apart from the hard red spring samples, none of the United States wheats gave stable curves. The hard red winter gave a much poorer curve than the Russian hard red winter, which is a further proof that the Farinograph data indicate only the behavior on mixing, because although the United States hard red winters were sensitive to over mixing, they were otherwise superior to the Russian wheats. The comparison of curves No. 43 and 45 is interesting. The former is a hard white wheat of 11.4 per cent protein (in the flour) and the latter is a soft white with a flour of 6.6 per cent protein. Any test of baking quality would place the latter as greatly inferior, yet it gives a better Farinograph curve indicating that it possesses qualities lacking in the hard white wheat. Baking tests showed that although lab No. 43 gave a large negative response to increased mixing, lab No. 45

gave a small positive response--a further illustration that the Farinograph measures the behavior of the dough during the mixing period and not baking quality.

The curve given by the club wheat (lab No. 42) was very typical of all club wheats, and bore a striking resemblance to the English wheat.

The Australian F. A. Q. wheats gave typically weak curves. Samples 9 and 11 rapidly reached the point of maximum consistency and gave very sharply defined "breaking points" at seven and eight minutes, respectively, but sample No. 10 gave a more stable curve. The best Farinograph curve was given by Pusa 4. The development at first was rapid and then very slow over a long period, the point of maximum consistency being reached after sixteen minutes; thereafter the fall was very gradual, the "breaking point" being clear-cut at thirty-five minutes. This type of curve is ideal and it is remarkable that a wheat of only moderately high protein content should give such a result. It can only be assumed that the quality of the protein is excellent, as the curve is equal to that generally obtained from wheats of 17 per cent protein.

Ford (lab No. 48) gave the best results of the other New South Wales wheats tested. The development was slow and similar to that of high grade Manitoba flour, but after reaching optimum consistency the dough quality rapidly depreciated. Dundee (lab No. 50) was better than average Australian but still of rather poor dough quality. Baringa (lab No. 49) showed a very pronounced weakness; the excessive quantity of water added to give the correct consistency caused the dough to be sticky from the start, and after seven minutes there was a pronounced break, and thereafter the dough lost all elasticity, and became merely a semi-fluid mass.

A blend of Ford and Baringa overcame the faults of the latter and a curve essentially the same as that of Ford was given. In this instance the Farinograph data support the conclusions previously arrived at by itself, on account of the poor handling quality of the dough, but when blended with a wheat of the right type, very satisfactory results may be obtained.

The results of the Farinograph tests show clearly that any relationship existing between type of curve and the baking quality of the flour, as determined by loaf volume, is purely incidental. The type of curve merely indicates the behavior of the dough during mixing, and it is ridiculous to suppose that information obtained during this period of twenty or thirty minutes' mixing is any indication of what will take place after several hours of fermentation.

Summary and Conclusions

Wheat from many of the important wheat growing countries of the world has been tested for milling and baking quality, and the wheat and flour milled therefrom submitted to the ordinary routine analyses.

In general, milling quality has been found to parallel baking quality, but there were some notable exceptions. The United States hard white wheats were milled with difficulty but the flour was, nevertheless, of very good baking quality. Again some Argentinian samples, which were very good milling wheats, were only of moderate baking quality.

The flours of highest diastatic activity were those milled from the hard red spring wheats, but three of the New South Wales samples were equally as good. Most of the soft wheats were of poor diastatic activity, and of this group the Australian F. A. Q. samples were the best. Some flours examined were of exceptionally low diastatic activity but it would appear that this was not due so much to the lack of the saccherogenic enzyme as to a high degree of starch resistance. In such cases even the addition of 0.6 per cent of diastatic malt failed to cause any change in loaf volume.

Contrary to popular belief, the carotene content of the Australian wheats tended to be greater than that of the Canadian wheats. It would seem, therefore, that the ability of Australian wheat to yield flour of good color is due mainly to the non-pigmented bran, enabling a flour of longer extraction and yet free from bran pigment to be milled.

The relationship between Pelshenke time and baking quality was very poor, but the coefficient of correlation between protein content and "malt-phosphate-bromate" loaf volume was 0.8653, which is a high correlation for wheats of widely different origin and type.

As a group, the hard red spring wheats of Canada and the United States were the best examined, but Pusa 4 excelled them in flour yield, was equally as good in baking quality when texture and crumb color were considered in addition to loaf volume, and gave a much better Farinograph curve.

The high quality of the United States hard red winter wheats which were next in order of baking quality should be recognized as largely due to a very dry season giving wheat a high protein content. In wet years they would not be of such high quality. There were intolerant of over-mixing, but were otherwise excellent wheats. Following the hard red spring wheats and the United States hard red winters, the order of baking quality was: Russian hard winters and the best Argentinian wheats (Bahia Blanca Barletta), United States hard white, soft red winter (United States). Argentinian and Hungarian, Australian, French German and Italian, and, last, the English and the United States soft white and white club.

The New South Wales varieties tested were considerably better than the average Australian wheats. Although Baringa gave a large loaf volume, the dough was of particularly poor handling quality, but by blending it with Ford, this could be rectified and a better loaf was produced than that by using either flour separately.

A comparison of the results obtained with the different baking procedures indicated that the "malt-phosphate-bromate" procedures were the most valuable, the placings being very similar to those using the mean loaf volumes of all tests. The "high yeast-high sugar-bromate" formula was disappointing, and as a single test of baking quality, the "malt-phosphate" was useless, the differentiation between flours particularly in the strong class being very poor.

The Farinograph data, in the opinion of the author, did not alter the order of quality of the samples examined as determined by the baking test, but served to support conclusions previously arrived at. The Farinograph is looked upon, not as a measure of baking quality, but as a means of predicting the behavior of a dough during the mixing period. The flours which gave the best curves were those which gave good responses to the three minute mixing period in the Hobart-Swanson machine.

The claim that the Farinograph may be used to determine accurately the water absorption of the flour is invalid. The correct water absorption of the flour is that quantity which will give a dough of the correct consistency at the time of panning, and in many cases there is a pronounced difference between this figure and the amount of water necessary to give a dough of the correct consistency at the time of mixing.

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