FACTORS ENTERING INTO THE USE OF CANADIAN WHEAT IN FOREIGN COUNTRIES

Factors Entering into the Use of Canadian Wheat in Foreign Countries.

by

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Contents.

Introduction.

Perhaps the most important problem facing Canada to-day is the problem of the disposal of her wheat. In recent years Canada has forged proudly ahead to become the "granary of the Empire" and the greatest exporting nation in the world. Our jubiliation over the bumper crop of 1928, however, was shortlived because of the unusual phenomenon that occured: the crop did not move out as it should have done. After that the piling up of the 1929 crop was not unexpected.

This thesis does not seek to apportion the blame for the failure to dispose of the crop, nor to advocate a panacea to cure the situation. In fact, the present situation is largely ignored, on account of the belief that it is the broad and more permanent causes that have a greater influence in determining the course of national economy than an accidental "Konjunktur" of events. The thesis deals, therefore, with such problems as the competition of wheat with rye and rice, a comparison of the quality of Canadian and foreign wheats, and so on, while the present situation is touched upon in the concluding chapter. The subject is not exhausted in this thesis. Indeed, the subject is so vast and complicated that an exhaustive treatment of it would practically cover the entire field of economics. All that is intended here is to point out a few of the more relevant factors and their particular relation to Canada.

The succeeding pages will be better understood if a brief description of wheat and flour is given here. Wheat is a grain. The kernel is composed of an undigestible outer covering, variously called spermaderm, pericarp, or branny coat, a seed or germ situated at one end of the grain, and the interior bulk of the grain called the endosperm. The process of milling consists in removing the branny coat and the germ and leaving as flour, the finely ground endosperm with a minimum amount of bran in it. In the process of milling a number of streams of flour of varying purity and "tailings" or milling offal are produced. When the purer streams are conbined to form a flour, it is called a "patent" If the residual streams are combined it is called a "clear." If all the streams are united in their natural proportions, the resultant flour is known as "straight" flour.

Chapter 1

The Place of Wheat in the Diet.

Bread has occupied an important place in the human diet since the earliest days of mankind. In the remotest beginnings of history we find man already familiar with the process of crushing wheat, cleaning the meal thus obtained, and baking the resultant flour into bread. As civilization progressed refinements in the art of milling were introduced, and we soon find that the quality of bread eaten becomes a distinction of the social classes. This distinction has remained until quite recent times. Now white bread is consumed by all classes in most west European and many American countries.

The reason for this popularity of bread is its cheapness. Owing to the small amount of moisture present in flour, a given weight of flour contains more nutritive solid material than does a similar weight of most of the other foods used by mankind. To understand the nutritive value of flour (or bread) properly, a description of its constituent parts is necessary. The following table shows the composition of flour as determined from three different sources to show the degree of similarity of different flours.

Composition of Wheat Flour (per cent)

According to:	Kent-Jones(1)	Swanson(2)	Duly(3)
Starch, Sugars } carbohydrates	65-70 $2\frac{1}{2}$	73.6	72.4
Proteins	9-14	11.0	10.75
Water	13-15	13.50	15.0
Cellulose		.25	0.2
Fat	1	1.25	1.25
Mineral Matter (Ash)	$\frac{1}{2}$	.4	0.4

Starch or carbohydrates, forms the greatest part of the flour. The percentage of carbohydrate in flour is farily constant. The fat content and the content of crude fibre or cellulose is also constant. The other three constituents of the flour may vary considerably and the extent of their presence or absence is very often indicative of the quality of the flour. The question of quality in wheat is discussed more fully below(4). The composition of wheat is naturally very similar to that of flour. The following table shows the constituents of wheat and also bran.

Composition of Wheat and Bran (per cent)

	Wheat		Bran
According to:	Kent-Jones(5)	Swanson(6)	Swanson(7)
Starch, Sugar } Carbohydrates	63-71 $2\frac{1}{4}$-$3\frac{1}{2}$	70.2	53.2
Proteins	10-15	12.0	15.4
Water	8-17	12.0	13.0
Cellulose	2- 3	1.8	9.0
Fat	$1\frac{1}{2}$-2	2.00	3.6
Mineral Matter(Ash)	$1\frac{1}{2}$- 2	2.0	5.8

(1) D.W.Kent-Jones:Modern Cereal Chemistry. p.1
(2) C.O.Swanson: Wheat Flour and Diet. p.118
(3) S.J.Duly: Grain. p. 149 (4) Vide Infra. Chap.4 (5) Op.cit. p.1
(6) Op. cit. p.118 (7) Ibid p.118.

We see that wheat is richer than flour in protein, cellulose, and mineral matter, while flour is richer in carbohydrates. Bran, being the part of the wheat removed to form flour, is the richest in proteins, cellulose, and mineral matter.

Before going on to discuss the food value of flour, a brief description of each of these constituents and the function they perform in nourishing the body is necessary.

Moisture content in flour does not play an important part in supplying nourishment to the body. While it is true that the body requires a considerable amount of water daily, this can be easily obtained from other sources, and the lack of moisture in flour does not detract from its food value. The lack of moisture is more important from the viewpoint that the small amount of moisture present in flour makes the flour a rather highly concentrated food, with a high calorific value per unit of weight.

The human body is constantly losing heat, both directly and through the use of heat as a source of energy of all kinds. This loss is made up from foods of three kinds: carbohydrates, proteins and fats. While these substances supply energy to the body they are not interchangeable. The carbohydrates and fats supply energy directly or are stored as fat in the human body. The proteins, in addition to supplying energy, are used to a great extent in building up the tissue of the body that is constantly being worn down. For this reason a given weight of carbohydrate will supply the body with more energy than a similar weight of protein. On the

other hand, while the body can exist for a length of time without being fed carbohydrates, proteins are essential for continued existence (1).

Starch is the chief carbohydrate present in flour. Since carbohydrates are such excellent sources of energy for the body and since starch forms so large a constituent of flour, it can readily be seen why bread is such an excellent source of energy. This fact seems to be appreciated by manual workers, and not only do we find them to be the greatest bread-eaters, but we find that when the standard of living of a community rises from a low to a higher level, it is often accompanied by an increased per capita consumption of bread(2).

Protein, the essential constituent of any diet, is present in wheat flour to a somewhat smaller extent. The proteins present in flour however, can not in themselves supply the needs of the human boddy. This is due to fact that proteins are a complex mixture of substances known chemically as amino acids, and some of these amino acids are missing from the proteins in the wheat kernel. Thus Kent-Jones(3) says:

> "The proteins of vegetables and cereals are, however, now believed to be of less bidogical value than animal proteins and require to be supplemented by the latter."

Fat is the third and most highly concentrated source of

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(1) Kent-Jones. Op.cit. p.6
(2) Stanford University Wheat Studies Vol. II. 8. p.288.
(3) Op. cit. p.46

human energy. A given amount of fat supplies more energy than an equal amount of carbohydrate or protein. Although fats and carbohydrates are interchangeable to some extent, a greater or less amount of fat is usually required. The amount depends upon the climate, the nature of a person's occupation, etc. The average requirement of fat per person in the British Isles has been estimated at about 75 grams a day (1). Wheat flour is deficient in fat. The small amount of fat present in wheat is further decreased by the removal, in milling, of the wheat germ which contains most of the fat. This is done because the oil in the germ turns rancid very easily; and the storing of flour containing the germ for a long period of time is very difficult on this account.

Mineral matter, another constituent of flour, is also present in the human body. The presence of the correct amount of mineral matter in the human body is essential for the general health of the person and especially for the proper formation and growth of the bones. Flour contains a rather small amount of mineral matter. In fact it is often the case that the mineral content of the flour is inversely correlated with its quality. Not only is flour lacking in total content of mineral matter but it is particularly poor in calcium, which is essential for the normal growth of the bones(2).

Cellulose or crude fibre is undigestible in the human

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(1) Kent-Jones: Op.cit. p.47
(2) Ibid. p.47

system, and when it is taken in with food it acts as roughage, that is, it supplies bulk which is considered necessary for the proper digestion of food. Flour contains very little cellulose, most of it having been removed as bran.

The sugar content of the flour is small and is not very important from a nutritive point of view. The sugar is much more important from the point of view that the quantity and kind of sugar present in tne flour has an important relationship to its baking quality.

Flour, therefore, contains a considerable amount of fuel energy, principally as carbohydrates, but also as proteins, and fats. It is, however, low in fat and mineral content, and the proteins and mineral content are lacking in some important constituents.

We may now turn to the question of food values. The food values of various substances are usually determined by three general methods: chemical analysis of the foods to determine the kind and amount of substances a food contains so as to see whether itcan replace the substances that are being used up by the body; digestibility, which means the determination the quantity of various substances that the body absorbs from each food; and finally, biological analysis or feeding experiments, which consist of feeding animals, human or otherwise, with prepared diets, and studying their health under these conditions.

The most widely known method of the first group is the determination of energy content or calorific value of various foods. The energy of food constituents is not the same when determined by burning (in a calorimeter) as when determined by the intake of an animal. The greatest difference is found in the case of protein, since a portion of the protein is used in building tissue. The following table shows the calorific value of the food constituents.

	Determined by;	
	Calorimeter(1)	Intake(2)
One gram of protein	5.6 calories(3)	4.0 calories
" " " carbohydrate	4.1 "	4.1 "
" " " fat	9.3 "	9.3 "

The amount of energy required by different persons depends upon their age, sex, and occupation. Thus children require less than adults, adult females less than adult males, and persons engaged in sedentary occupations less than those doing strenuous work. Kent-Jones(4) gives the following daily average calorie requirements for the various classes of persons.

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(1) Swanson, Op.cit. p.134.
(2) Kent-Jones, Op.cit. p.45.
(3) Calorie: the amount of heat required to raise the temperature of 1 gram of water from 15°C. to 16°C.
(4) Op.cit. p.45.

Children	-	6 years	1,650	Calories
"	-	6 - 10 years	2,300	"
"	-	10- 14 years	2,750	"
Females	-	14 years and upwards	2,750	"
Males	-	14 years " "	3,300	"

The British Army peace ration is fixed at 3600 Calories a day. Swanson (1) gives the following average energy requirements for the different groups.

	Protein (Grams)	Fuel Value (Calories)
Children - 1-2 years (average)	28	765
" - 2-6 " "	55	1,420
" - 6-12 " "	75	2,040
Very poor people usually without work Very rich people usually without work ?	69	2,100
Women at light muscular work	90	2,400
Women at moderate muscular work	100	2,700
Business men, student	106	3,285
Farmers and mechanics	100	3,425

Although different authorities do not give quite the same figures these figures may be taken to be approximately correct. It must be noted that these figures are averages only. Thus while 3,300 calories is the average for adult males, a tailor requires only 2,750 calories daily, while a stonemason requires 4,850 calories. The following table give the energy values of certain foods, so that they may be compared with the energy requirements.

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(1) Op. cit. p.136

		(1)	(2)
1 Pound of	White Bread	1,037 Calories	1,200 Calories
	Brown "	1,012	
	Sugar		1,815
	Potatoes		375
	Eggs	659	672
	Rump Steak)	2,006	
	Sirloin)	1,749	
	Leg of Mutton)	1,501	700-1,800
	Leg of Pork)	1,262	
	Bacon (back))	2,696	
	Chicken	360	
	Milk	303	314
	Herring	687	
	Cabbage	192	
	Butter	3,502	3,500
	Margarine	3,579	
	Cheese (full cream)	2,011	

We see that apart from some meats and dairy produce, bread has the highest calorific value per pound. When price is considered, bread is undoubtedly the cheapest food that will supply the human body with its necessary store of energy.

Next to the problem of energy value is that of digestibility. For obviously a food, although high in energy value, would be a poor nutritive if only a small amount of it were absorbed by the human system. The following table(3) shows the percentage of digestibility of the various classes of foods.

	Proteins	Carbo-hydrates	Fats
Meats	97	--	95
Dairy Products	97	98	95
Cereals	85	98	90
Mixed diets	92	98	95

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(1) Kent-Jones. Op.cit. p.45.
(2) Swanson. Op. cit. p.135.
(3) Ibid p.140

It is evident that the digestibility of cereal protein and fat is rather lower than that of meats and dairy products. On the other hand the factor of the rate of digestibility is also of considerable importance. Those foods that are digested slowly are often said not to "agree" with people and are therefore avoided. Since baked bread consists of a mass of very thin cell walls, it is acted upon very easily by the digestive juices and is therefore said to "agree." This is one of the reasons why white bread is so popular.

We see, therefore, that bread is an excellent source of energy. However, provision of a sufficient amount of bodily energy is only one function of the diet. That is, the diet must supply a sufficient amount of energy otherwise the body will be undernourished, but it must also supply other things as well. The other things that a diet must supply are: adequate material for repair, and growth in the case of the young; sufficient vigour to be resistant to disease; capability of the race to reproduce and to bring forth healthy children.

To discover a diet that would fulfil these requirements students of nutrition have evolved the principle of the balanced diet. The term "balanced diet" merely means a diet that will supply all the nutritive requirements of the human body. It is in the attempt to establish such a diet that most of the knowledge of nutrition was discovered. Thus the first attempts at balanced diets merely essayed to establish a diet that would contain a suf-

ficient amount of carbohydrates, proteins fats, etc. It was soon found that supplying the human body with a sufficient total amount proteins was not sufficient, it was also necessary for each of the constituent amino acids to be present in sufficient quantity. The total number of amino acids required is 18 (1). Wheat does not contain this number, and a diet in which wheat is the sole source of proteins would be deficient. The supplementary proteins may be obtained from meat, fish, milk and cheese. Although other cereals also contain proteins it is dangerous to rely upon them to make up this deficiency, because they, too, are probably deficient in the same amino acids(2). We may note in this connection that the minimum average daily intake of protein is now usually held to be 100 grams(3). One peculiar feature about wheat proteins is that apart from their own biological value, they yield an increased value when taken in conjunction with other proteins. That is, the total biological value of the two proteins taken together is greater than the sum of their separate biological values. This is illustrated by the following examples(4):

Nitrogen of wheat flour taken with nitrogen of:	Total Biological Value If taken separately	If taken together	Gain "
Whole egg	66	75	11
Milk	62	71	9
Beef	60	73	13

(1) Kent-Jones. Op.cit. p.46
(2) Swanson. Op.cit. p.143
(3) Kent-Jones. Op.cit. p.46
(4) Ibid p.47

Another group of nutritives, the "minerals" must also be present in sufficient quantities individually and not merely in total amount. The two important minerals in this respect are calcium and phosphorus. In wheat flour and bread, the phosphorus content is somewhat deficient and the calcium content greatly so. If nervous disorders are to be avoided, and a proper growth of the bony structure is to be maintained, this deficiency must be compensated by the addition to the diet of milk, vegetables, legumes, tubers(1), etc.

However, it has been found comparatively recently, that a diet that fulfils all the requirements outlined above, may still be unable to maintain life if the ingredients are fed to the subjects in purified form. This seeming contradiction finally led to the discovery of the substances called vitamins. The exact chemical composition of these substances is not clear, nor is their nature or their properties thoroughly known. At present there are five comparatively well known vitamins. They are called vitamin A,B,C,D, and E. The following list describes the more important properties of the vitamins(2) (the word "vitamine" was introduced in 1912 by Casimer Funk):

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(1) Swanson. Op.cit. p.145 et.seq.
(2) The discussion of vitamins given here is based on Kent-Jones: Op.cit. p.51 et.seq. and Swanson: Op.cit. pp.156-178.passim.

Vitamin	Solubility	Function by Which it is Recognized
A.	Fat soluble	Essential for young animals as it is the growth factor.
B.	Water soluble	Anti-neuritic (anti-beri beri). Essential for normal nutrition.
C.	Water soluble	Anti-scorbutic (anti-scurvy).
D.	Fat soluble	Anti-rachitic and hence essential for young animals.
E.	Fat soluble	Anti-sterility in both sexes.

Vitamin A is essential for growing children. It is also necessary for adults if they wish to continue in good health. This is a common property of all vitamins: their absence causes illnesses known as deficiency diseases. Lack of vitamin A in children's diets causes kidney disorders, skin diseases, and diarrhea. Its lack also greatly lowers resistance to bacterial infection and leaves a person exposed to such diseases as bronchitis, pneumonia, and tuberculoses. Vitamin A occurs irregularly in foods. It is found in cod liver oil, green leaves and green vegetables, many animal fats and butter. It is destroyed by light and oxidation.

Vitamin B is also necessary for growth. It is anti-neuritic for all ages, it stimulates the appetite, and strengthens the body generally. It occurs widely in foods. It is found in green leaves, tubers, eggs, milk and nuts. It is not present in sufficient quantities in the muscle meat that is usually eaten as meat by human beings. The covering of the wheat, or bran, is rich in vitamin B, but it is almost completely absent from the endosperm. This vitamin is fairly resistant to heat.

Vitamin C is the anti-scorbutic vitamin. It is also essential to children for proper growth, and its absence increases susceptibility to infectious diseases. It is very sensitive to heat, and thus, although raw milk contains this vitamin, pasteurized milk does not. A child fed on pasteurized milk should therefore be given orange juice, or juice from green vegetables. Vitamin C is also found in other citrous fruits, and in tomatoes.

Vitamin D is peculiar in the fact that it does not seem to nourish the body directly but it enables the body to utilize the mineral manner taken into the system. It is anti-rachitic, that is it prevents rickets when present, and cures rickets when it is given to the patient. It is found chiefly in cod liver oil. It can be synthesized by the human body when exposed to light. It can also be synthesized in substances containing cholesterol when they are irradiated with ultra-violet light.

Vitamin E is the anti-sterility vitamin, Animals brought up on a diet lacking this vitamin were sterile. However there is little danger of there being a deficiency of this vitamin in the human diet since it occurs very widely in foods. Muscle meat, lettuce, and the wheat germ are rich in vitamin E.

We see therefore that white bread is lacking in vitamins. White bread is often attacked on this ground, especially for its lack of vitamin B. It is claimed that the "unnatural" process of milling white flour, which removes the bran and germ, both rich in vitamins, proteim, mineral content, greatly diminishes the food

value of the flour, and of the white bread baked from it. Some people therefore advocate the use of entire wheat bread or Graham bread. The former flour contains the wheat germ and some bran, and is an 85 per cent extraction of wheat. The latter flour contains the entire wheat kernel. The bread made from these flours, it is claimed, is much more nutritive, is a better food, and contains an abundant supply of vitamin B.

In the first place, many authorities claim that the yeast in modern bread supplies a sufficient amount of vitamin B(1); and in any case bread should not be looked upon to furnish the total vitamin requirements in a diet. These must be obtained elsewhere. With regard to the other qualities claimed for entire wheat bread, they are of doubtful value. Although the addition of the bran and the germ adds proteins and minerals to the flour, the digestibility of the bread is so reduced by the addition of bran that the total amount of nutrition it can yield is less than the amount obtainable from white bread(2). Kent-Jones comes to the conclusion that while a certain amount of brown bread may be beneficial to sedentary workers with sluggish digestive systems, the great mass of people can derive more nourishment from white bread than from brown. Furthermore, the flour of white bread can be stored more easily and for a greater length of time than that of

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(1) Kent-Jones. Op.cit. p.52
(2) Ibid. p.56.

entire wheat bread which soon turns rancid. From an economic point of view, it is more profitable to feed human beings on white bread, and use the milling offals to feed animals which can digest the bran(1).

The critics of white bread as well as the critics of all bread base their criticism on the fact that bread when eaten alone is an inadequate food. This is correct. However the inferences drawn from this fact are often incorrect. It does not follow that merely because bread in itself is not a complete food, it should therefore be condemned. We must bear in mind that there is no food in use at present that, by itself, will adequately supply all the needs of a diet. To condemn bread for this reason would mean that we would have to condemn every other food eaten by mankind. Furthermore, the deficiencies in bread, are easily made good by the addition of other supplementary foods to the diet. The resulting diet is not something very complicated or difficult, but is merely the ordinary diet of people who have sufficient means to feed themselves properly(2). The very fact that there is no prevalence of deficiency diseases in the wheat-eating countries shows that the ordinary diets are not lacking in vitamins. The following extract from the report of the British Medical Research Council(3) in 1924, is rather conclusive:

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(1) Kent-Jones. Op.cit. p.66

(2) A simple example of such a diet would include bread,meat, fish,boiled and raw vegetables of various kinds (potatoes, cabbages,lettuce,tomatoes,etc.), raw and prepared fruits, dairy products.

(3) Kent-Jones. Op.cit. p.53

> "In modern European life, under normal peace conditions, the risk of these deficiency diseases although a real one where infants are concerned, may be regarded as non-existent for adults; the great variety of food taken ensures that an adequate amount of preventive vitamines is regularly consumed."

We may therefore conclude that wheat is not a complete food. It is lacking in vitamins, some proteins, and mineral matter However, this deficiency can, and is, made good by supplementary foods in an ordinary balanced diet. Wheat is a cheap and concentrated source of the energy required by the body. Bread baked from wheat is palatable, easily digestible and can supply the body with most of the energy it requires. The proteins in bread enhance the value of the proteins in eggs, meat, and milk when taken together. There is no evidence to show that bread occupies too prominent a place in the diet to-day. In fact the evidence points in the opposite direction. Thus the French have a healthful diet although half of the calories in the Franch diet are from bread. In the same way Kent-Jones(1) says about the diet in the United States:

> "If the bread consumption were advanced to 40 per cent (from less than 30 per cent, the actual percentage) of the intake - - still leaving plenty of room for the necessary vitamin containing foods - - there would be a pronounced cheapening of the diet in the price sense, without the least deterioration in the quality sense."

The actual place that wheat occupies in the diet is

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(1) Op. cit. p.47

difficult to determine for various reasons. First, an estimate of per capita consumption of wheat is a residual calculation, and as such reflects all the errors made in calculating wheat production, movements, disappearance, etc. Then it is difficult to estimate the amount of waste incidental to the preparation and consumption of the wheat products. With these qualifications, the following table shows the relative importance of wheat in the diet of various countries(1).

France	7.8	Roumania	4.2
Belgium	6.7	Jugo-Slavia	4.0
Italy	6.6	Holland	3.8
New Zealand	6.4	Czechoslovakia	3.4
British Isles	5.7	Algeria	3.4
Chile	5.5	Austria	3.2
Spain	5.5	Egypt	3.2
Bulgaria	5.3	Sweden	3.0
Argentina	5.2	Tunis	2.8
Hungary	5.0	Norway	2.3
Greece	5.0	Germany	2.2
Denmark	4.8	Portugal	2.1
United States	4.8	Finland	1.6
Canada	4.5	Union of South Africa	1.5
Switzerland	4.4	Poland	1.3
Morocco	4.3	India	1.0
Uruguay	4.2	Japan	0.9
		Mexico	0.8

We see from this table that there is room for an enormous increase in wheat consumption by the nations of the world before bread could be said to occupy too important a place in their diet. The actual changes that will take place are problematical.

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(1) Broomhall: Corn Trade Year Book 1929 p.16.

As we shall see below, the per capita consumption in the British Isles, Canada and the United States had declined within the last two decades. It is probable that the per capita consumption of these countries listed above as small consumers of wheat will increase with a rise in the standard of living. The rate or the extent of this increase in consumption is problematical, and the influence it will have on international trade in wheat is more problematical still. All that we can say definitely is that with wheat prices at their present low level, there will probably be a distinct increase in the per capita consumption of bread, especially in Europe (1).

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(1) cp. Wheat Studies 111. 9. "Reactions in Exporting and Importing Countries to Changes in Wheat Prices."

Chapter 2

Cereals That Compete With Wheat.

Rye.

Wheat and rye are the only two cereals whose dough will rise on fermentation and is capable of being baked into bread. Doughs from other grains can be baked into biscuits or quick breads, but they cannot produce yeast leavened bread. This property separates them from all other cereals, and for this reason they are known as the bread grains.

Historically, wheat is the older grain, dating back to prehistoric times. Rye (secale cereale) seems to have been introduced into Europe after the Christian era. Its use spread widely, and at the beginning of modern times, it was the predominating bread grain in Europe. It was the predominant grain in Great Britain and was widely grown in Spain, France, Italy, the Danube Basin, and Russia: in short in all those regions that are now pre-eminently wheat producing and wheat consuming regions. Rye bread was also the staple food of early North American colonial days(1).

Since the beginning of the 19th century wheat has been steadily displacing rye as a bread grain. At present rye cannot be called a world grain. Its production in Australia and Africa is negligible, and if we include western Siberia in Europe, it is grown to a very limited extent in Asia (2). It is grown in North

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(1). Wheat Studies. IV.5. p.186
(2) Vierteljahrshefte zur Konjunkturforschung, Sonderheft 20.N. Jasny: Die Zukunft des Roggens. p.90.

and South America, Europe, and Russia. Its most important area of growth and consumption is in the latter two areas. In Europe the area heavily sown to rye starts somewhat east of Belgium and extends over the northern half of Germany, Czechoslovakia, Austria, Poland, north and central Russia, into Siberia. It extends south in Europe until it reaches the corn zone, and north beyond the spring sown cereals. Rye is most firmly established in those regions where the soil has been exhausted by wheat or the land and climate is ill suited for wheat growing. As a consequence, the areas sown to rye often yield a low return per acre (1).

The rye grain is somewhat similar to wheat in composition. It is covered by an outer coating which forms the bran, and the interior consists mainly of endosperm, with the germ or embryo lodged at one end of the grain. The rye grain is rather smaller than the wheat grain and contains a smaller percentage of endosperm. As a result, wheat grains yield a larger percentage of flour than rye grains, an extraction of 74 and 68 per cent respectively yielding flours of comparable quality. Rye also differs from wheat in chemical content.

Rye has somewhat less fat than wheat, and the starch content of its endosperm is greater. However, rye is distinctly inferior in protein content. Thus the protein content of rye ranges from about 7.5 per cent in soft German ryes to about 12.5 per cent in hard Plate (Argentine) ryes. The best European ryes seem to be

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(1) Vierteljahrshefte zur Konjunkturforschung. Sonderheft 20.N. Jasny: Die Zukunft des Roggens. p.91

the Russian ryes which have as high (1) a protein content as 10.9 per cent(2). This low protein content is in sharp contrast with wheat which rarely has a protein content below 10 per cent, and may contain over 15 per cent protein. Rye protein does not contain gluten. As a consequence, rye dough lacks the spring and elasticity of wheaten dough, and its bread is small and heavy(3).

The rye plant is more hardy than the wheat plant(4). It can withstand greater extremes of cold and moisture. In general rye can be grown wherever wheat is grown, and in many regions where wheat cannot be grown. It has, therefore a greater potential acreage than wheat. Rye can withstand severe changes in weather such as late frosts, excessive or insufficient moisture, and requires less snow cover, etc., than wheat. Rye can also yield fair crops on wheat exhausted or marginal land. Excepting ergot, rye is less susceptible to parasitic and pest damaging than is wheat. In regions favorable to wheat, wheat will yield a larger crop. In unfavorable regions, rye will yield the larger crop. In Europe, rye seems to be firmly established in the rotations of the soil practised by the peasants. In short, growing rye tends to be profitable from every viewpoint except the economic viewpoint.

The rye plant may be divided into two classes, hard and soft rye. Hard rye makes the better bread and for this reason is

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(2) Kent-Jones: Op.cit. p.72
(3) Ibid p.74
(4) Wheat Studies. IV.5. p.182

preferred by bakers. Generally speaking, hard rye is found only in Russia and the Danube Basin in Europe. The rye area of central and eastern Europe produce, with minor exceptions, only soft rye. Argentine rye is hard rye. Indeed the growth of the rye export trade in Argentina is largely due to the export of hard rye to Europe where it is mixed with the soft European rye. United States exported rye is mostly soft rye.

Rye production in America is an excellent example of a war boom in an industry. Owing to the high prices paid for rye, the acreage sown to rye expanded enormously, from a pre war average of 116 thousand acres to a peak of 2,105 thousand acres in 1922-23 in Canada, from about 2.3 million acres to about 6.7 acres in 1922-23 in the United States, and from less than 100 thousand acres in Argentina to some 400 thousand acres in 1924(1). Except in the case of Argentina where the acreage has continued to increase the acreage sown to rye has declined rapidly after the boom period. The following table shows the production of rye compared to wheat, in various countries, and for the whole world.

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(1) Wheat Studies IV. 5. p.188

Estimated(1) World Wheat and Rye Average Annual Acreage and Production (ex-China and Asia Minor).

	Acreage (million acres)		Production (million bushels)	
	Wheat	Rye	Wheat	Rye
1909-13	270	110	3,772	1,485
1926-29	310	114	4,352	1,505

Approximate Production of Wheat and Rye in Various Countries (2) (3).

	Wheat 1926-29	Rye 1926-29	Rye 1909-13
Russia	750	900	750
Germany	110	300	380
Poland	50	240	230
Finland & East Baltic	5	36	50
Czechoslovakia	40	65	--
France	280	35	50
Scandinavia	20	35	43
Hungary	75	30	32
Iberia	150	27	32
Austria	10	20	22
Belgium	15	22	23
Jugoslavia	75	7	2
Roumania	100	10	5
United States	860	46	36
Canada	440	13	2
Argentina	240	6	.6

We see from the first table that ~~while~~ there has been a considerable increase in the world wheat acreage and production, while the acreage and production of rye has remained almost stationary.

The slight importance of the rye crop in America is

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(1) International Yearbook of Agricultural Statistics 1929-30. tables 52 and 53.

(2) International Yearbook of Agricultural Statistics 1929-30. p.147 and Wheat Studies. V11.2. p.167

(3) Note: These figures are not averages but approximations given for the purpose of comparison.

evident from the second table. In the United States where rye is most widely grown, it forms less than 5 per cent of the wheat crop, in Canada and Argentina, it is less than 1 per cent. In Europe rye occupies a much more important position. More rye than wheat is produced in Russia, Germany, Poland, the areas adjacent to the Baltic, Czechoslovakia, Austria, and Belgium.

Comparing pre and post war production figures, we find that the production of rye has decreased in all countries of Europe with the exception of Russia, Poland, Roumania and Jugoslavia. The only important increase has occurred in Russia, where production has increased by some 150 million bushels. In America, there has been a greater proportionate increase in the production of rye than in Russia, although the total increase in only about 2.5 million bushels. In all these countries, however, with the possible exception of Russia, the post war average rate of production has been well maintained in recent years, and there is no sign that rye production is diminishing at present(1).

Before the war, international trade in rye was confined largely to Europe and Russia. Argentina and the United States made small shipments to Germany and Great Britain. Russia imported some rye from Germany, but was a net exporter of rye. Germany was also a net exporter of rye to adjacent countries. Austro-Hungary was a net importer of rye. The total net imports of Europe, ex-Russia,

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(1). cf. Wheat Studies Vll. 2. p.169

from 1909-1910, were about 40 million bushels per annum (compare with some 620 million bushels of wheat imported annually).

Stimulated by the war, and the demand for foodstuffs from the European allies, exports of rye from America rose to 15 million bushels in 1915, and to a maximum of 47 million bushels in 1920-21, and has subsequently established itself at about 35 million bushels per annum(1). The imports are now used as straight bread flour or for mixing with wheat flour. International trade within Europe has dwindled considerable since the war. At present the Danube Basin is the only area consistently exporting rye. Their exports averaged less than 8 million bushels annually (1926-29)(2). Russia's exports have also declined and are now (1926 and 1927) slightly more than half the amount exported annually before the war, in spite of the fact that what were foremerly wheat importing areas in northwest Russia are now ex-Russian.

Rye is milled into flour in a fashion very similar to the milling of wheat. In Europe the ryes are blended with imported wheats to form flours of uniform quality, to suit the taste of the discriminating consumer. This is not done in America to any extent. Rye flour very often contains a considerable proportion of bran in it. The straight rye flour, that is flour practically free from bran is a 68 per cent extraction. "Graham-rye" is an extraction of

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(1) Wheat Studies. IV. 5. pp.228 and 229.
(2) International Yearbook of Agricultural Statistics 1929-30. p. 279.

some 96 per cent of the rye grain. The most popular rye flour in Europe at present, seems to lie about half way between these two extractions(1). The bran does not detract from the marketable value of the flour since rye flour is dark in any case. Rye flour cannot be stored as long as wheat flour. Harder types of rye are used to make flour for urban consumption while softer ryes are made into flour for the country.

Rye flour is baked into bread in bakeries in Europe. Domestic baking is almost unknown there. Rye bread is baked in smaller and less up-to-date bakeries. The larger, more modern bakeries usually bake only wheaten bread. As is often the case in North America, the wheaten bread and rye bread do not compete with each other, they are largely supplementary. There is, of course, no one particular standard of quality of rye bread in Europe. There are breads of all kinds, depending for their quality on the kind of flour and other ingredients used, method of baking etc. However, the predominating rye ("black") bread(2) is made from straight rye flour, ferment, salt, and water, and no other ingredients. This produces a loaf quite different in its properties from American white bread which has been described as a poor sort of cake, on account of the sugar, milk, shortening, etc., it often contains. Due to the inelasticity of the dough, rye breads are smaller, coarser, and lack

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(1). Wheat Studies IV.5.p. 203.
(2) Ibid p.209.

that light crisp texture of white breads. Rye breads also have a sour taste because of the acidity and peculiar taste of the rye. This is not a disadvantage from the consumer's point of view. Indeed it is claimed that people accustomed to rye bread dislike wheaten bread because they find its taste insipid(1). In comparing American with European bread we must always bear in mind the fact that in Europe bread is a food, while on this side of the Atlantic it is regarded merely as a filler.

It is often claimed that rye bread is less digestible than wheaten bread. A comparison between the two is made difficult because there are so very many kinds of both breads. The constituents, namely protein, starch, fat, etc., seem to be of equal digestibility. It is probably, however, that rye bran is less digestible than wheat bran. If, therefore a comparison is made between breads made from patent flours (flours that contain almost no bran), they will probably be found to be of equal digestibility. However, the ordinary rye bread, with its relatively large bran content, and its thick, heavy texture (making it less accessible to the digestive juices)isprobably less digestible than the ordinary light, flaky, white bread(2).

Per capita consumption figures of rye are lacking for post war periods. Before the war the per capita consumption of rye

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(1). Kent-Jones. Op.cit. p.71
(2). Wheat Studies. IV.5. p.193

flour was 240 pounds in Russia, 133 pounds in Germany and 94 pounds in Austro-Hungary. The following table(1) shows the annual pre and post war per capita disappearance of flour in pounds:

Country	1909-14	1921-26
Belgium	210	155
Denmark	510	325
Germany	360	245
Netherlands	250	151
Sweden	280	220

The decline in per capita disappearance is too great to be explained on any other basis than a decline in the consumption of rye. This is the opinion of all observers, although it difficult to obtain accurate statistical evidence to substantiate this belief. With the rise in the standard of living and a general revulsion against the rye bread especially in Central Europe where it was made notorious by war conditions, there is an undoubted tendency for wheat to replace rye as a bread base in spite of Government propaganda supporting rye (2). The effect that this movement will have on international trade in wheat is obscure. Rye is firmly established as a rotational crop in Europe and is used for other purposes besides human consumption. If, however the consumption of rye decreases considerably, much land now sown to rye will probably be sown to wheat. As this land is poor land it will not yield a high return of wheat, and increased wheat imports

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(1) Ibid. p.198
(2) Kent-Jones. Op.cit. p.71

will be needed to supplement the domestic crop. The rate of this increase cannot be foretold, but there is no reason to believe that it will be conspicuously great.

Rice.

Rice is a grain used as a food staple chiefly in the Orient. Although it is used as an article of consumption universally throughout the world, it is only in the East that it is consumed in large quantities. Wheat differs from rice in this important respect, that in the countries where wheat is consumed it forms at the most only 50 per cent of the diet (by calories, in France(1)). This diet includes meat, dairy produce, vegetables, etc., and can be properly called a balanced diet.In the Orient, however, rice is the predominating food. Taking Japan as a typical example(2) we obtain the following distribution of food consumption (1925):

Item	Percentage
All plant foods	91.75
All cereals	70.85
Rice	50.83
Barley	10.15
Wheat	6.63
Other Cereals	3.24
All legumes	8.47
Roots and Tubers	9.65
Potatoes	8.63
Other	1.02
Other Plants	2.78
All animal foods	2.95
Fish	2.43
Meat & Poultry	0.27
Eggs and milk	0.25
Sugar	5.30

(1) Kent-Jones. Op.cit. p.47
(2) Wheat Studies Vl.8. p.365

Thus, while the percentage of rice in the Japanese diet is not greater than that of wheat in the Franch diet, it is of much greater importance from the physiological viewppint, because over 90 per cent of the diet is of plant origin.

Asia is the great rice growing continent. Of a total annual world production(1) of 865 million quintals (1926-29), Europe produced 10 million quintals, Russia some 4 million, North America about 10.5 million, Africa some 25 million, South America some 10 million, and Asia over 800 million quintals. The figures for China, being unobtainable, are omitted from the total. The greatest rice producers in Asia are southern China, India, Japan, Indochina, Siam, Korea, and the Philippines. The international trade in rice is rather small. The total net exports (1926-29 average) were about 65 million quintals(2), or about 8 per cent of the total production. The corresponding figure for wheat is almost 20 per cent .

The rice grain is not unlike wheat in its composition. The following table(3) shows its percentage composition in various stages of cleaning, compared to that of rice.

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(1) International Yearbook of Agricultural Statistics. 1929-30. p.165.
(2) Ibid. p.307.
(3) Kent-Jones. Op.cit. p.88.

Content	Rice				Wheat
	Unhusked	Husked	Skinned	Polished	
Moisture	11.50	12.38	13.38	12.82	8-17
Fat	1.74	1.52	.31	.22	15-2
Protein	6.50	7.24	6.59	6.61	10-15
Carbohydrates	66.19	76.88	79.03	79.74	65-74
Crude Fibre	7.93	.85	.29	.29	2-3
Ash	5.14	1.13	.40	.32	15-2

The usual form of consumption of rice in the Orient is husked rice. This form of rice contains an amount of moisture and fat about equal to that of wheat. However, it is much lower in protein and ash content, and somewhat higher in carbohydrates. The low protein and ash content must make the rice diet a rather unbalanced one. This is accentuated by the removal of the husk which contains vitamin B(1). Deficiency diseases are therefore common in rice eating countries. However, wheat does not seem to be well adapted to balance this diet. It is a cereal, somewhat deficient in proteins and vitamin B. Whsat is needed to balance the diet is a food with a high and balanced protein content and rich in vitamin B.

SStatistically, wheat consumption is increasing rapidly in most of the rice consuming countries(2), but wheat is of such minor importance that the absolute increase is very small. Thus while the Japanese consumption of flour increased from 10.6 pounds per caput in 1905-07 to 18.6 pounds in 1923-27, the consumption

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(1) Kent-Jones. Op.cit. p.51
(2) Wheat Studies. Vl.7. p.384

of flour increased by 3.3 million barrels(1). In the same way the per capita consumption of tropical Asia increased from 3.43 pounds of flour in 1909-13 to 5.08 pounds in 1923-27, while the total consumption increased by some 5 million bushels(2). We may therefore conclude that the trend of wheat consumption is upward in Asia, but slowly upward.

It is interesting to note that replacement of rice by the potato(3) is more likely to occur than the replacement of rice by wheat. The potato has been introduced into the Orient relatively recently and is making rapid strides there. It is better suited to Oriental methods of agriculture than wheat. The potato gives a greater yield per acre and requires more labor per acre. In the Orient, where land is scarce and labor plentiful, the potato should spread rapidly.

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(1) Wheat Studies Vl.8. p.362
(2) Wheat Studies Vl.7. p.348
(3) Wheat Studies Vl.8. p.365

Chapter 3.

A Comparison of the Quality of Wheat Grown in Important Areas of Production.

1. Wheat-Exporting Countries.

It is generally believed, in a vague fashion, that Canada produces wheat superior in quality to that of any other country, and that this gives Canada a distinct advantage in marketing her wheat, since she presumably has a monopoly in the market for wheat of the best quality. In this chapter the truth of this statement will be analysed, and an attempt will be made to determine the extent of Canada's supposed advantage.

Quality in wheat has a different meaning to the various people interested in this commodity. To the farmer it means a kind of wheat that will give a high yield per acre, a wheat that will resist drought, disease, and other accidents of nature. In short, a wheat so adapted to its environment that it will yield him a large crop of sound, plump wheat kernels, with a high test weight per bushel.

To the miller, good quality in wheat does not mean exactly the same thing. Wheat is of good quality to him when it will yield a high percentage of white or creamy flour of a uniform standard of quality. To do this, the wheat must be not only sound and plump, but also largely free of foreign material, of all kinds of other grains, of damaged kernels, and of other

grades or kinds of wheat.

Sound kernels indicate that the wheat has not been damaged in any way. Wheat that is plump and has a high test weight per bushel, will yield a large percentage of flour, and a small amount of bran. If the foreign material present in the wheat is of such a nature that it can be easily removed before milling the wheat, then it does not affect the quality of the wheat from the miller's viewpoint, unless it imparts an objectionable odour to the wheat. If, however, the foreign material is such that it cannot be removed before milling, it may greatly influence the value of the flour produced. Modern milling depends on the difference in the hardness between the coat (which is converted into bran) and the endosperm (the floury part). If the kernels are damaged by frost, excessive moisture, etc., the relative change in the hardness of the constituent parts, may make milling a difficult or expensive task. Bakers also like a flour of standard quality, this can be more easily obtained by the miller if all the wheat in one parcel is of the same class and grade.

The baker is interested primarily in a flour that will give him the greatest number of large, well piled loaves of good appearance, from a given amount of flour. The following baking characteristics are usually indicative of the quality of the flour tested: time taken in fermenting and proofing, water absorption of the flour, the volume weight and break and shred of the loaf, the texture and color of the crumb, and the color of the

crust. The longer the fermentation or proofing time, before the gluten begins to deteriorate the greater is the power of the dough to withstand punishment and neglect without giving poor results on being baked. This is an important factor in mechanized bakeries. If a flour can absorb more than an average amount of water, it usually means that the flour is not only "strong", but that it is also profitable to the baker, since water ordinarily costs less than flour. Loaves of greater volume are more digestible than loaves of less volume baked from the same amount of flour. The other terms are self explanatory.

The general term "strength" used to define the quality of wheat and flour, is difficult to explain accurately. This is partly due to the different meanings of the term when employed by different authorities. Bailey(1) states the following about this question:

> "The term "flour strength"..... has been employed in describing several properties of flour, including (a) the quantity of water absorbed per unit of flour in preparing a dough of standard consistency; (b) the quantity of bread produced per unit of flour; (c) the physical extensibility of dough as indicated by the manner in which it handles in the bakeshop; and (d) the capacity of the flour to make large, well-piled loaves. The last definition was suggested by Humphries (1905), and is most commonly used."

Kent Jones (2), however, qualifies definition (d), he says:

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(1) C.H.Bailey: The Chemistry of Wheat Flour. P.228.

(2) D.W. Kent Jones: Modern Cereal Chemistry. P.130.

> "Definitions on the size of loaf are therefore open to serious objections unless it is realized that a loaf may be small from at least two causes: too weak flour and too strong flour....With them (the existing definitions of strength) to be strictly logical a flour has a different strength according to the baker who uses it."

It is also generally agreed that a flour is "strong" if, on its being mixed with a flour admittedly "weak", the resultant blend produces satisfactory loaves of bread.

These different qualities of wheat emphasized by the different viewpoint of the various groups handling wheat and flour all play a part in determining the value of any particular parcel of wheat. In this chapter we are interested primarily in those qualities desired by millers and bakers because it is the presence or absence of these qualities that determine the relative value of different wheats in the world market.

Factors determining the quality of wheat may be roughly divided into three groups. First there is the variety or strain of wheat that is sown. Then there is the environment and physical features of the locality in which the wheat is grown, that is, soil, climate and moisture. And thirdly there is the yearly changes and fluctuations in temperature and moisture which affect each year's crop. Each one of these affects the quality of the crop, but the first one is the only one that can be changed at will. Different varieties of wheat have their own characteristic qualities which make them more suitable to be grown in certain localities than in others. Indeed some of the most important work

done by state agricultural departments is the determining and development of suitable strains of wheat for particular localities. Permanent climatic features cannot be altered and the adaptability of wheat strains to the environment is limited. The consequent combination produces wheats that come to be known as characteristic of each region. Annual fluctuation in climatic conditions exert an important influence on the quality of each year's crop, but as they cannot be predicted or subjected to uniform laws they will be disregarded in the following discussion. This can be done the more readily since they merely produce greater or smaller variations in the established characteristics of the crop usually harvested in that area.

Wheat is never uniform in quality throughout any large area. However, it would not be profitable to subdivide minutely the areas considered. Such procedure would add little to the accuracy of the analysis, and merely confuse the discussion. Comparisons will therefore be made only between wheats of entire countries or producing areas.

The most important characteristics of the wheat and flour that are determined by analysis may be grouped under two heads, milling results and baking results. These correspond to the characteristics described above as being desirable from a milling and baking viewpoint. The significance of the baking results has been explained. Among the milling results, the ash in the flour is usually inversely proportional to the quality of the

flour, other things being equal. About the acidity as pH, Kent-Jones (1) quotes Sharp and Gortner to the effect that the maximum viscosity, that is swelling power of the dough was at pH 3 and pH 11. Therefore in the wheats considered, those with a lower pH rank higher on that account. The gluten quality index (Gortner Angle b), presumably shows a higher score for gluten of superior quality, but Kent-Jones states that this is not always so and that the index should be employed with caution. (2). The protein content usually determines the baking characteristics, a high protein content means that the baking properties will be excellent and vice versa. However the quality of the protein is also important, and it often happens that a flour of lower protein content of good quality gives more satisfactory results than one with a higher protein content of poorer quality.

It is extremely difficult to make a comparison of the qualities of the wheats of different countries, because the analysis of these wheats is usually done in the countries where they are grown, and the results are presented in different forms so that comparison is very difficult if not impossible. Or else, if the analysis is done by a group of experts in one country, it is done on different varieties of wheat grown in that country, which, of course, differ from the same wheats when grown in their native countries because of the different environment.

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(1) Ibid. P.142.

(2) Ibid. P.143.

However, the United States Department of Agriculture has recently published a bulletin called "Milling and Baking Qualities of World Wheats." This bulletin compares the milling and baking qualities of samples of wheats sent to Washington, which were actually grown in the countries they represent and are supposed to be fair examples of the year's crops, usually 1926-27. 852 samples in all were tested. Of these, 421 were varietal samples and 431 were samples of export wheat. These latter samples were taken from cargoes actually exported. Samples were received from all countries in the world producing wheat to any extent, with a few exceptions. Of the wheat-exporting countries Roumania and Jugoslavia are omitted. Of those importing wheat, Algeria, Austria, China, France and Finland are missing. The following discussion is based largely on this bulletin, supplemented by information from other sources. (1).

The tests that the wheat was submitted to were all made in the experimental laboratories of the Department of Agriculture. The wheat was first graded according to United States standards, and the amount of dockage was determined. The wheat was then milled in the experimental mill in the laboratory. After which the dough was prepared and the bread baked according to a standard formula. The keynote of the whole experiment was to treat all the samples exactly alike so that the results obtained should be properly comparable.

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(1) The bulletin is United States Department of Agriculture Technical Bulletin No.197, October 1930. Called "Milling and Baking Qualities of World Wheats." It will be referred to in future as U.S.Bulletin, 197.

For the present purpose it is not necessary to consider either all the samples of each country nor the samples of every country. The information we require can best be obtained by comparing the averages of samples of the most important wheat varieties grown in the most important countries from the point of view of international wheat movements. We shall consider the major wheat exporting countries first.

Canada's total wheat production is over 400 million bushels annually (average 1924-28). Of this some 310 million bushels were exported annually during this period. This places Canada as first among the wheat-exporting countries of the world.(1) Canadian wheat is mostly hard red spring wheat. Winter wheat is grown in Canada, but it forms less than five per cent of the total crop. The variety Marquis is most widely grown in Canada. It forms about 90 per cent of the spring wheat crop. (2)

Since we are primarily concerned with the quality of Canadian export wheat, we can omit fall wheat from this discussion, as little or no fall wheat is exported from Canada. The following tables show the properties of Canadian wheat. In these and in similar tables averages for the number of samples indicated are given.

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(1) Stanford U. Wheat Studies. Vl.10. P.167.

(2) U.S. Tech. Bull. 197. P.20

Canadian Export Wheats: Description and Characteristics. (1)

Reference No.	Samples Analyzed	Class	Grade	Dockage %	Kernel Texture %	Test Weight per Bushel Pounds	Damaged Kernels %	Foreign Material other than Dockage %
1	31	Hard Red Spring	1 Man. Nor.	.6	93.6	62.0	.4	.2
2	3	" "	do tough	.6	93.4	62.1	.3	.2
3	33	" "	2 Man.Nor.	.6	88.2	61.4	1.1	.2
4	12	" "	do tough	.7	87.2	61.3	1.0	.4
5	28	" "	3 Man.Nor.	.7	77.1	60.5	4.9	.4
6.	3	" "	do tough	.7	81.5	60.3	3.6	.4
7	14	" "	4 Man.Nor.	.9	73.8	59.9	17.8	.4
8	7	" "	5 Man.Nor.	1.3	71.6	58.8	40.9	.6
9	3	" "	6 Man.Nor.	2.1	61.2	56.9	64.1	1.6
10	1	" "	Feed	4.3	60.6	52.9	60.4	4.0
Average	135	" "		.8	83.8	60.9	7.4	.4

Canadian Export Wheats: Milling Properties and Certain Chemical Characteristics.

Reference No.		1	2	3	4	5	6	7	8	9	10	Av.
Test Weight per bushel.	lbs.	62.2	61.9	61.5	61.5	60;7	60.3	60.0	58.9	57.3	53.7	61.0
Screenings and scourings removed.	%	1.9	1.4	1.9	2.1	2.1	1.7	2.1	2.9	4.1	6.1	2.1
Foreign material in wheat as milled.	%	.1	.1	.1	.1	.2	.2	.2	.3	1.1	3.2	.15
Moisture content of wheat	%	11.8	11.4	11.3	12.1	11.5	11.9	12.1	12.3	12.1	12.8	11.7
Flour yield basis cleaned and scoured wheat	%	72.0	71.0	71.0	70.7	70.5	71.5	69.6	67.4	64.7	62.4	70.6

(1) Taken from U.S.Tech.Bull. 197. P. 28 et seq.

Canadian Export Wheats: Milling Properties and Certain Chemical Characteristics.(Continued).

Reference No.	1	2	3	4	5	6	7	8	9	10	Av.
Flour yield basis dockage free wheat %	71.1	70.4	70.1	69.7	69.5	70.8	68.8	66.3	62.4	61.3	69.6
Wheat per bbl.of flour lbs.	271	272	273	277	276	272	280	292	309	317	276
Milling Texture	Hard	Hard	Hard	Hard	Hard	Hard	Hard	Hard	Hard	Hard	Hard
Texture of flour	G(1)	G	G	G	G	G	G	G	G	G	G
Color of flour,visual	SC (2)	W(3)	W	W	SC	W	SC	W	SC	SC	SC
Color of flour,gasoline value	1.03	.86	1.10	1.03	1.10	1.09	.96	.95	1.07	....	1.04
Ash in flour %	.47	.46	.47	.48	.48	.52	.49	.51	.57	....	.48
Acidity: pH	6.54	6.55	6.56	6.54	6.54	6.55	6.56	6.53	6.53	....	6.54
Acidity: lactic acid %	.270	.257	.283	.266	.292	.289	.305	.399	.379	....	.288
Crude Protein in wheat %	1362	1351	1333	1322	1292	1324	1256	1241	1217	....	1314
in flour %	1290	1269	1260	1255	1212	1258	1171	1158	1096	....	1238
Gluten quality index	1.90	1.86	1.90	1.97	1.90	1.94	1.96	1.99	2.16	....	1.92

(1) G - Granular.
(2) SC - Slightly Creamy.
(3) W - White,

Canadian Export Wheats: Baking Properties.

Reference No.	1	2	3	4	5	6	7	8	9	10	Av.
Fermentation time. Min.	138	150	137	146	139	138	148	147	144	159	141
Proofing time. Min.	61	62	61	62	62	59	64	60	58	53	61
Water absorption of flour %	59.6	61.9	59.4	60.0	59.9	58.7	62.4	65.2	64.8	67.8	60.9
Volume of loaf. cc.	2061	2060	2085	2088	2146	2193	2163	2178	2193	2200	2110
Weight of loaf. Grams	507	512	508	508	507	507	509	515	518	516	508
Color of crumb. Score	87	87	87	87	86	87	85	84	80	64	87
Grain of crumb. Score	89	89	90	90	90	89	88	88	88	82	89
Texture of crumb	Good	Good	Good	Good	Good	Good	Good	Very Good	Good	Good	Good
Shade of color of crumb	C(1)	SC (1)	SC	C	C	C	SCG (1)	DCG (1)	DCG	SG (1)	C
Color of crust	B(1)	B	B	B	B	B	B	B	B	B	B
Break and shred	Good	Fair	Very Good	Very Good	Very Good	Fair	Very Good	Very Good	Good	Good	Good
Bread per barrel of flour. Pounds	292	295	293	293	292	292	294	297	299	297	293

Summarizing the data in the above tables we find the first three grades - Nos. 1, 2, and 3 Manitoba Northern, to be of very high quality. The wheat weighed over 60 pounds per bushel in each case, and was practically free from dockage and other undesirable material. Milling produced a flour of good color, high protein, and low ash content, and the percentage of flour obtained was high. In baking, the water absorption was uniformly high,

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(1) C - Creamy SC - Slightly Creamy SCG - Slightly Creamy Gray
DCG - Dark Creamy Gray SG - Smutty Gray B - Brown

although the loaf produced was somewhat small than the average. The other properties of the bread baked were excellent. The lower grades showed increasing properties of dockage and damaged kernels as the grade became lower. The flour milled from them produced a bread which was inferior in color and had a higher ash content. The water absorption was higher than in the better grades, due to the characteristic properties of frost damaged wheat, and the volume of loaf was greater. In view of the small volume of loaf obtained from Canadian wheat, the following extracts from Kent-Jones are interesting(1). He says that Canadian spring

> "is a wheat much like the Northern Spring, but, possibly because grown on less exhausted land, it is stronger than the American wheat.... It should be borne in mind that Manitoba wheat is occasionally deficient in diastase.... The addition of a little malt extract would have made all the difference to the loaf (in the case where lack of diastatic activity in the dough led to disappointingly small loaves being produced). As a rule this lack of diastase is not found in the lower grades. Millers would often be wise if other conditions allowing it.... they substituted for a small proportion of the No. 1 some No. 3 for example."

In the United States various classes of wheat are grown. They are (2) in the order of their importance - (taking the average of the crop from 1920 to 1928) - hard red winter wheat, 300 million bushels or 36.3%; soft red winter, 215 million bushels or 25.8%; hard red spring wheat, 160 million bushels or 19.2%;

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(1) Ibid P. 24.

(2) Tech. Bull. 197. P. 48.

white wheat, 85 million bushels or 10.5%; and durum wheat, 70 million bushels or 8.2%; making a total average crop of approximately 830 million bushels for the nine years considered.

The exports of wheat-including flour - from the United States are roughly - average of 1920 to 1928 - as follows (1): hard red winter, 75 million bushels or 48.5%; durum, 30 million bushels or 12.9%; soft red winter 20 million bushels or 12.9%; white, 20 million bushels or 12.9%; and hard red spring 10 million bushels or 6.4%, making a total average of about 155 million bushels of wheat exported. The figure of 155 million bushels is largely due to the inclusion of the years 1920 and 1921, when exports were very heavy. If these years are excluded, the total average export of wheat (excluding flour) from 1922 to 1928 is 128 million bushels. If we include wheat flour, the figure is about 175 million bushels. The following tables show characteristics of United States wheat as determined by testing samples taken from cargoes of wheat exported from the United States (2).

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(1) Ibid P. 57.

(2) Ibid P. 58.

United States Export Wheats: Description and Characteristics.

Reference No.	Samples Analyzed	Class	Grade	Dockage %	Kernel Texture %	Test Weight per Bushel Pounds	Damaged Kernels %	Foreign Material other than Dockage %
1	1	Hard Red Spring	1 Dark Nor. Spring	.8	80.9	60.2	2.4	1.1
2	14	" "	" "	.3	84.3	59.3	1.0	.6
3	11	Durum	2 Amber and Mixed Durum	1.8	66.7	61.1	2.3	1.9
4	33	Hard Red Winter	2 Hard Winter	1.0	58.5	60.2	.9	1.2
5	34	" "	" "	.3	51.5	60.0	1.3	1.3
6	23	Soft Red Winter	2 Red Winter	.4	....	59.7	2.6	.6
7	40	" "	" " "	.1	....	60.0	2.1	.7
8	16	White	Mixed	1.2	80.3	59.5	.4	.4
9	30	"	"	.7	....	61.1	.2	.4

United States Export Wheats: Milling Properties and Certain Chemical Characteristics.

Reference No.	1	2	3	4	5	6	7	8	9
Test Weight per bushel.	59.4	59.9	61.1	61.3	61.1	60.1	60.3	59.8	61.3
Screenings and scourings removed.	2.3	2.3	4.1	3.4	2.9	3.1	2.8	3.8	3.5
Foreign material in wheat as milled.	0.3	.3	1.2	.8	.8	.2	.3	.1	.1
Moisture content of wheat	13.1	10.5	12.0	11.0	10.3	11.0	10.3	11.2	10.2
Flour yield basis cleaned and scoured.	71.3	70.1	72.0	71.8	71.6	70.6	70.6	69.5	71.1
Flour yield basis dockage free wheat.	69.6	68.7	70.4	70.2	69.8	68.9	68.8	68.2	69.1

United States Export Wheats: Milling Properties and Certain Chemical Characteristics (Continued).

Reference No.	1	2	3	4	5	6	7	8	9
Wheat per bbl.of flour	280	276	274	271	271	276	275	280	274
Milling Texture	Hard	Hard	VH (1)	Hard	Hard	Soft	Soft	Soft	Soft
Texture of flour	G(1)	G	G	G	G	Soft	Soft	Soft	Soft
Color of flour,visual	SC (1)	SC	C(1)	W(1)	W	W	W	W	W
Color of flour,gasoline value.	0.98	1.29	1.57	1.49	1.48	1.20	1.22	1.21	1.07
Ash in flour	0.47	.50	.67	.51	.52	.48	.49	.50	.51
Acidity: pH	6.40	6.50	6.53	6.45	6.51	6.40	6.44	6.51	6.47
Acidity: lactic acid	0284	.319	.290	.300	.306	.326	.332	.305	.348
Crude Protein in wheat	1258	1278	1202	1062	1091	1022	1026	1100	1094
Crude Protein in flour	1218	1196	1127	1004	989	9.23	9.08	9.89	9.77
Gluten quality index	2.18	2.02	2.51	2.23	2.22	2.08	2.21	2.26	2.29

(1) VH - Very Hard G - Granular SC - Slightly Creamy
C - Creamy W - White

United States Export Wheats: Baking Properties.

Reference No.	1	2	3	4	5	6	7	8	9
Fermentation time. Min.	131	148	136	139	137	112	116	114	116
Proofing time. Min.	61	65	63	63	65	62	65	58	62
Water absorption of flour %	59.0	58.2	60.7	58.2	57.7	53.3	53.6	54.8	54.6
Volume of loaf. cc.	2240	2156	2029	2112	2176	2098	2152	1970	2074
Weight of loaf. Grams	512	501	512	504	501	490	488	498	494
Color of crumb. Score	88	87	84	87	88	88	89	87	88
Grain of crumb. Score	93	91	89	91	91	87	89	84	87.9
Texture of crumb	Good	Good	VG (1)	Good	Good	Fair	Fair	Poor	Good
Shade of color of crumb	LCG (1)	LC (1)	VC (1)	C (1)	LC	LC	SC (1)	C	CY (1)
Color of crust	....	B (1)	B	LB (1)	LB	LB	LB	LB	LB
Break and shred	....	Good	U (1)	Fair	Fair	Poor	Poor	Poor	Fair
Bread per barrel of flour. Pounds	295	289	295	290	289	283	282	287	285

These tables are informative about different questions. Samples no.1,3,4,6, and 8 are averages of samples taken from cargoes exported during 1926-27, Samples no. 2,5,7, and 9 are averages of composite samples of wheat exported during 1926-27, taken and tested every month. By comparing the two averages thus obtained for each class except durum, an excellent idea of the reliability of these tests may be obtained. On the whole, the data given is

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(1) VG - Very Good LCG - Light Creamy Gray LC - Light Creamy VC - Very Creamy C-Creamy SC-Slightly Creamy CY-Creamy Yellow B-Brown LB-Light Brown U-Unsatisfactory

consistent, there being no important differences between the two samples of the same class.

Comparing the United States wheats among themselves, we find the following. The hard red winter wheat compared very favourably with the hard red spring wheat. While the dockage and percentage of other foreign material was higher in the winter wheat, it yielded a slightly higher test weight per bushel. The spring wheat had a decidedly higher kernel texture, 80.9 and 80.3%, compared to 58.5 and 51.5%. The winter wheat yielded a slightly higher percentage of flour, although its ash content was also slightly higher. The gluten content of the winter wheat was distinctly lower, although its quality was better. In baking properties the spring wheat scored higher almost throughout although the pounds per barrel of flour of the more representative sample, no. 2, was about equal to that of the winter wheat. About the hard winter, Kent-Jones (1) says:

> "Generally speaking, Hard Winter, although not, of course, in the same class as Manitoba is fairly strong....Taken on the whole it is a consistent wheat."

The soft red winter wheat was, as was to be expected, inferior to the two classes just mentioned. It had a fairly high test weight per bushel, 60.1 and 60.3 lbs. gave a satisfactory yield of flour, but produced a soft white flour of low protein content. Its baking properties were correspondingly low, producing a loaf with small volume and low weight and with a poor break and shred. Kent-Jones (2) says:

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(1) Ibid P.27 (2) Ibid P.29

> "This wheat yields flour of a rather weak type, but the color is generally good. Its color is usually better than Hard Winter but it is not so strong.... It is an especially suitable wheat.... for weak pastry flours."

The durum wheat showed the usual characteristics of that class, and ranked very high in most quality tests, but produced a loaf of small volume yellowish color, and unsatisfactory break and shred. The results obtained from the white wheat samples were inconclusive because the samples included in the average were so varied, no. 9 in the table gave higher results than no. 8. The test weight per bushel was rather high, and the wheat yielded a soft white flour of a somewhat low protein content. The quality of bread produced was poor in almost every respect. Kent-Jones(1) describes them as being

> "normally, wheats of low protein content and of poor strength. The stronger varieties (Hard White) (are) not strong like the Northern Spring wheat, but...of more medium strength."

When we compare the hard red spring and winter wheats of the United States with those of Canada, we obtain some interesting results. It is unfortunate that the results for the United States wheats are not given grade by grade, but even so, we may obtain some useful information. The texture of No.1 Manitoba Northern is 93.6%, while that of No.1 Dark Northern Spring is 80.9% and 84.3%. That of No. 2 Hard Winter (United States) is 58.5% and 51.5%, lower than no. 6 Manitoba Northern which is 60.6%.

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(1) Ibid P.29

It is not until we reach No.3 Manitoba Northern that the texture (77.1%) drops below that of No.1.Dark Northern Spring. As the kernel texture, other things being equal, bears a closs relation to the baking quality of the flour produced (1), this implies that the Canadian wheats tend to be superior to United States hard wheats in baking quality. Again in test weight per bushel, it is not until we reach no. 4. Manitoba Northern that we find a test weight 59.9, equal to or lower than that of No.1.Dark Northern Spring 60.2 and 59.3, and No. 2 Hard Winter, 60.2 and 60.0. In the percentage yield of flour, they are about equal; in pounds of wheat per bushel of flour the United States winter seems to be slighily superior and the United States spring slightly inferior to the Canadian. The ash content of the Canadian wheat is lower. The gluten content is distinctly greater in the Canadian that in the United States winter, and considerably greater than in the United States spring, but the quality of the Canadian gluten seems to be decidedly inferior to that in the United States wheats. With reference to the baking qualities, the water absorption of Canadian flour was higher, and the weight of loaf was also distinctly higher, but in volume of loaf the United States wheat was decidedly higher. In color and grain score the United States wheats were slightly inferior but in break and shrdd and bread per barrel of flour, Canadian wheat ranked definitely higher. All in all, when

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(1) Tech.Bull. 197 P.9

we compare no.2 Manitoba Northern with the United States wheat, it is inferior in almost every test, the only exceptions being volume of loaf and gluten quality; and it is only infrequently when Manitobas are deficient in diastase, that the Canadian wheat is inferior in these qualities. This is in agreement with Kent-Jones' (1) opinion. He describes United States Northern Springs as

> "the strong wheats of the United States. -Northern Springs were amongst the strongest, and inconsequence, best liked wheats in the world... Of recent years the Northern Spring wheat has been much weaker than Manitoba."

Next in importance to Canada and the United States, in the international trade of wheat, is Argentina. Argentina ranks third among the wheat exporting countries of the world, with an average export of some 155 million bushels of wheat (1924-1929). Her wheat production averages (1924-1930)½ 230 million bushels, it is centered (2) in the provinces of Buenos Aires and Cordoba where about 70% of the wheat is grown, and the province of Santa Fe and Entre Rios and the territory of La Pampa. These areas together produce some 95% of the Argentine crop. The most common variety of wheat in Argentina is Barletta, a hard red winter wheat. It is grown widely as it is well adapted to the soil and climate conditions found in the Argentine. It furnishes an abundant crop of kernels that show good milling and baking quality. It is highly resistent

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(1) Ibid P.24

(2) Tech. Bull. 197 P.78

to drought, rust, hail, excess heat or cold, damp fog, and late frosts. It does not shatter easily and can thus resist the strong winds during the ripening season. Ruso, a commercial variety is grown widely in the western part of Buenos Aires and in La Pampa. It is now losing its prominent position in these areas,and is being replaced by Kanred and other purevarieties. In the north, only durum is grown, due to soil and climatic conditions.

The export wheats of Argentina are known by their commercial names. As these names refer to the area in which the wheat is grown and also to the part from which it is shipped Argentine wheat usually contains a mixture, not only of varieties, but also of commercial classes. This, of course, is a considerable defect in the eyes of the miller who dislikes mixed classes of wheat for the reasons outlined above. At the same time, if the mixtures contained fairly constant percentages of each class, their undesirability might be minimized, but judging from the samples analyzed(1) this was found not to be the case. Thus the samples of Baril wheat (so called because it is either Barletta or Russo or both , and is usually shipped from Buenos Aires) contained from 19.6% to 91% of hard red spring wheat. The average for all the samples was 36%. They also contained an average of 7.4% of soft red winter wheat, varying in individual cases from .5% to 13.9%. 56% of the wheat was hard red winter. It also ranged from 43.2% to 90.5%. Barusso,

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(1) Tech. Bull. 197 P.88

another commercial variety also consists of Barletta or Ruso, but is grown further south and shipped from the port of Bahia Blanca. It, too, is a mixture of commercial classes. The samples contained from 58.9% to 96.3% of hard red winter wheat, hard red spring in percentages ranging from 4.9% to 35.7%, and from .8% to 15.8% of soft red winter wheat. The commercial variety Rosafe, consists of wheat grown in the regions of Santa Fe and Rosario and shipped through the Port of Rosario. It contained an average of 79.9% of hard red winter, 13.7% of soft red winter, and 5.8% of hard red spring wheat.

Argentine (1) Wheats: Description and Characteristics.

Reference no.	Samples Analyzed	Class	Grade	Crop Year	Dockage %	Kernel Texture %	Damaged Kernels %	Foreign Material other than Dockage %	Test Weight per Bushel Pounds
1	6	Hard Red Winter	Baril 3 Mixed	1926	2.0	55.0	0.7	1.3	56.4
2	3	" "	Baril 2 Mixed	1927	1.6	42.6	1.8	.7	60.0
3	17	" "	Barusso 3 Mixed	1926	2.5	58.0	.9	1.5	57.0
4	7	" "	Barusso 2 Mixed	1927	1.7	58.6	1.5	.9	59.6
5	1	" "	Entre Rios 4 Mixed	1926	1.2	55.0	.0	.8	54.8
6	6	" "	Rosafe 4 Mixed	1926	1.7	48.2	1.1	.8	54.5
7	2	" "	Rosafe 2 Mixed	1927 1	.9	51.7	2.4	.2	59.8
8	5	" "	Rosafe 2 Mixed	1927	1.0	54.5	2.4	.4	59.1
9	2	" "	Plate 3 Mixed	1926	2.3	62.5	1.0	1.3	56.4

(1) Tech. Bull. P.86 et.seq.

Argentine Wheats: Milling Properties and Certain Chemical Characteristics.

Reference No.	1	2	3	4	5	6	7	8	9
Test Weight per bushel.	56.3	60.9	57.4	60.5	55.5	54.7	60.0	60.5	56.3
Screenings and scourings removed %	4.4	3.2	4.5	3.5	4.7	4.0	2.4	2.0	4.9
Foreign material in wheat as milled%	.5	.2	1.0	.5	.2	.1	.1	.2	.4
Moisture content of wheat %	11.4	12.0	11.6	12.0	12.2	11.8	12.0	12.4	12.4
Flour yield basis cleaned and scoured%	66.9	70.4	66.9	70.2	66.9	63.6	67.8	68.9	68.1
Flour yield basis dockage free %	65.2	69.3	65.1	68.5	64.2	61.8	66.9	68.1	66.4
Wheat per barrel of flour. Pounds	294	278	295	281	301	311	288	284	291
Milling texture	Soft	SH(1)	SH	SH	Soft	Soft	Soft	Soft	SH
Texture of flour	Soft	Soft	G(1)	G	Soft	Soft	Soft	Soft	G
Color of flour visual	W(1)	W	W	LC (1)	W	W	W	LC	W
Color of flour gasoline value	1.12	.82	1.07	1.00	1.06	1.11	.97	.94	1.08
Ash in flour %	.48	.51	.50	.51	.43	.47	.50	.50	.51
Acidity of Wheat P:pH	6.40	6.54	6.30	6.53	6.40	6.32	6.60	6.60	6.50
lactic acid %	.365	.327	.344	.334	.306	.356	.309	.332	.308
Crude protein in wheat %	1045	1090	1109	1171	1355	1086	1205	1170	1064
flour %	9.70	1023	1019	1080	1269	9.65	1102	1067	9.80
Gluten quality index	2.46	2.28	2.34	2.24	2.25	2.41	2.19	2.28	2.33

Argentine Wheats: Baking properties.

Reference No.	1	2	3	4	5	6	7	8	9
Fermentation time.Min.	130	143	128	146	121	122	158	148	142
Proofing time. Min.	60	62	62	64	59	61	67	62.6	60
Water absorption of flour %	55.9	54.8	56.1	56.2	55.7	55.6	56.2	56.8	54.0

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(1) SH-Semi-hard G-Granular W-White LC-Light Creamy

Argentine Wheats: Baking Properties (Continued).

Reference No.	1	2	3	4	5	6	7	8	9
Volume of loaf. cc.	2100	2090	2193	2137	2510	2210	2226	2166	2070
Weight of loaf. Grams	496	482	498	494	495	497	492	493	494
Color of crumb. Score	88	90	87	87	89	88	89	88	86
Grain of crumb. Score	90	90	91	90	94	92	91	90	90
Texture of crumb	Good	Good	Good	FG (1)	E(1)	VG (1)	VG	Good	Good
Shade of color of crumb	C(1)	C	C	C	LCG (1)	C	C	LC (1)	CG (1)
Color of crust	B(1)	B	....	B	....	....	B	B	B
Break and shred	Fair	Fair	Fair	FG	....	....	Fair	Fair	FG
Bread per barrel of flour. Pounds	286	278	287	284	285	286	283	284	284

The test weight per bushel, which is the best index of milling quality, was low for the 1926 crop, the average test weight being 56.4 pounds for Baril, 57 pounds for Barusso, 54.5 pounds for Rosafe, and 54.8 pounds for Entre Rios. The test weight per bushel of the 1927 crop was much higher. It was between 59 and 60 pounds for the above varieties. However, judging from other sources,(2) the weight per bushel of the 1926 crop may be regarded as more typical of the average Argentine crop. The 1927 crop was well above the average in quality. The protein content which was,

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(1) E-Excellent FG-Fairly Good VG-Very Good C-Creamy LCG-Light Creamy Gray LC-Light Creamy CG-Creamy Gray B-Brown

(2) Wheat Studies IV. 1. P.7, and V.1. P.50

in most cases, between 10% and 11% in the 1926 crop was somewhat below the usual percentage found in Argentine wheat (1). The quality of the 1927 crop was better in this respect, the percentage of protein ranging in most cases from 11% to 12%. As might be expected, Baril and Barusso have about the same milling characteristics and are of about the same quality. Rosafe wheat was inferior to both Baril and Barusso, especially in the samples from the 1926 crop. Kent-Jones describes these wheats as follows:

> "Rosafe Plate (2) has invariably shown great inconsistencies....Thus,while Rosafe Plate is often a very profitable and useful wheat, the greatest care in selection must be taken as the variations are so wide.... This is true to a certain extent of all Plate wheats, but it is decidedly more the case with Rosafe than with the others."

> "It (3)(Barusso) is more dependable than Rosafe for one does not encounter the extremes of strength spoken of in connection with Rosafe....Plate wheats are considered by millers to be good filling wheats, for while they are not, as a rule, strong enough to carry weaker wheats, they do not require for themselves much help from the stronger ones."

> "In general it (4) (Baril) resembles the Barusso wheat....It is dangerous to use a very high percentage of Plate wheat in a blend, unless the necessary gassing power....is otherwise (supplied)."

No conclusion can be formed about the Entre Rios wheat because only one sample was tested. This sample was of excellent quality.

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(1) Wheat Studies IV.1. P.7
(2) Op. cit. P.33
(3) Ibid P.33
(4) Ibid P.34

Comparing the export wheats of Canada and Argentina we find the following. Canadian export wheat is a hard spring wheat, Argentine export wheat is a hard winter wheat. The average test weight per bushel of all the samples of Canadian export wheat was 60.9 pounds, of Argentina 56.3 pounds in 1926; kernel texture, 83.8% and 55.8% respectively; flour yield, 70.6% and 64.6% in 1926 and 69.3% in 1927. The average number of pounds of Canadian wheat per barrel of flour was 276, while that of Argentina was 298 for the 1926 crop, and 283 pounds for the 1927 crop. Percentage of ash was .48% for Canadian wheat and .49% for 1926 Argentine crop, and .51% for the 1927 samples. Crude protein averaged, respectively 13.14% and 10.97% in 1926, and 11.67% in 1927. Comparing the baking qualities of the wheats of the two countries we find that the fermentation and proofing time of the Canadian wheat was longer than that of the 1926 Argentine crop, but shorter than that of the 1927 crop. Water absorption was much higher in the Canadian wheat, the figures being 60.9% and 56% respectively. Volume of loaf was 2,110 cubic centimeters, and 2,181 cubic centimeters; weight of loaf 508 grams and 497 grams; color score 87 in both cases, grain of crumb 89 and 91; and pounds of bread per barrel of flour 293 pounds and 286 pounds respectively.

It is thus evident that the Argentine wheat of 1927, which was above the average in quality, was inferior to the Canadian wheat in almost every respect; and that this was even more true of the Argentine crop of 1926. The only characteristics in which the Argentine crop was superior, were in volume of loaf, grain of crumb,

and
gluten quality index. The Argentine wheat did not yield very satisfactory milling qualities with its relatively low test weight per bushel, large number of pounds per barrel of flour, and low protein content. From the point of view of baking quality, the Argentine flour did not display the characteristics of "strong" flour, with its low score in water absorption, bread per barrel of flour, and break and shred. That is to say, the flour could not be used to mix with weak flours to strengthen them. However, it is not a weak flour, and does not need to be mixed with stronger flours to improve its quality.

Australia is fourth among the wheat exporting countries of the world. Her exports for the crop years 1924-25 to 1929-30 averaged 90.9 million bushels (1), while her crops for the same period averaged 151.2 million bushels. Thus Australia exported, during this time, an average of 60% of her crop. The production of wheat in Australia centres largely in two crescent-shaped areas situated near the south-eastern and south-western coast of the island(2). The former is by far the larger of the two. The area of production is limited by climatic conditions in the east and lack of transportation facilities in the west. White wheat (3) is by far the most important variety grown in Australia. Durum and club wheats are not grown commercially. The amount of red wheat

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(1) Wheat Studies V11. 10. PP. 167 and 173.
(2) H.S.Patton: Papers in the World's Wheat Trade. P. 44.
(3) Tech. Bull. 197. P.204.
(4)

grown is very small and is decreasing steadily. Experts from Australia consist almost entirely of white wheat. The following tables show the characteristics of Australian hard and soft white wheats. The samples were taken from cargoes actually exported(1).

Australian Export Wheats: Description and Characteristics.

Reference No.	Samples Analyzed	Class	Grade	Dockage %	Kernel Texture	Test Weight per bushel Pounds	Damaged Kernels %	Foreign Material other than Dockage%
1	10	White	1 Hard White	.7	84.6	60.7	.1	.3
2	2	"	1 Soft White	.5	73.6	60.3	.0	.5
3	12	"	Total Average	.7	82.8	60.6	.1	.3

Australian Export Wheats: Milling Properties and Certain Chemical Characteristics.

Reference No.	1	2	3
Test Weight per bushel	60.8	60.8	60.8
Screenings and scourings removed %	3.3	2.7	3.2
Foreign material in wheat as milled %	....	....	.....
Moisture content of wheat %	11.6	12.2	11.7
Flour yield basis cleaned and scoured %	73.4	72.1	73.2
Flour yield basis dockage free %	71.7	70.7	71.5
Wheat per barrel of flour. Pounds	268	274	269
Milling Texture.	Soft	Soft	Soft
Texture of flour.	Soft	Soft	Soft

(1) Ibid P.207 et seq.

Australian Export Wheats: Milling Properties and Certain Chemical Characteristics (Continued).

Reference No.	1	2	3
Color of Flour:			
Visual	White	White	White
Color of Flour			
Gasoline value	1.42	1.60	1.45
Ash in flour %	.51	.45	.50
Acidity of wheat as			
pH	6.44	6.62	6.47
Lactic acid%	.220	.214	.219
Crude protein in			
Wheat %	10.44	9.41	10.27
flour %	9.59	7.98	9.32
Glutan quality index	2.43	2.30	2.41

Australian Export Wheats: Baking Properties.

Reference No.	1	2	3
Fermentation time. Min.	114	133	117
Proofing time Min.	60	67	61
Water absorption of flour %	54.8	54.8	54.8
Volume of loaf.cc.	1,979	1,995	1,982
Weight of loaf. Grams	498	492	497
Color of crumb.Score	87	86	87
Grain of crumb.Score	88	90	88
Texture of crumb.	Good	Good	Good
Shade of color of crumb	Creamy	Creamy	Creamy
Color of crust	LB (1)	Pale	LB
Break and shred	Poor	Fair	Poor
Bread per barrel of flour. Pounds	287	283	286

Australian wheat was of excellent milling quality; it had a high test wight per bushel, 60.6 pounds (the average test weight

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(1) LB - Light Brown

of the Canadian export wheat was 60.9 pounds), it yielded a large percentage of flour, 73.2%, the corresponding Canadian yield was 70.6%, and required 269 pounds of wheat per barrel of flour, Canadian wheat required 276 pounds. However, it produced a soft wheat. In protein and ash content, Canadian wheat was superior, the figures were: protein content, Canadian 13.14, Australian 10.27; ash, Canadian, .48, Australian .50. In baking quality, the Canadian and Australian wheats compared respectively, as follows: fermentation time 141 and 117 minutes; proofing time equal; water absorption, 60.9 and 54.8%; volume of loaf 2,100 and 1,982 cubic centimeters; weight of loaf, 508 and 497 grams; bread per barrel of flour 293 and 286 pounds; they were about equal in the other baking properties except break and shred, in which the Canadian bread was decidedly superior. It is evident from the baking properties described that Australian wheat is not among the strong wheats, but it is not so deficient in strength as to require admixtures of stronger wheats to bring it up to approved milling strength. It is a good filler wheat. Kent-Jones says:(1)

> "There is but little doubt that either the Australian wheats have increased appreciably in strength of recent years, or theidea that they were particularly weak was a mistaken one. The Australian wheats are not strong, but in this respect resemble the Plates....Australian wheats are consistent wheats, giving high yields of flour....like the Plates, they are very poor gassing wheats and are therefore much improved by the addition of one pound of malt flour a sack."

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(1) Ibid P.34

The agricultural area known as the Lower Danube Basin, includes the four countries Hungary, Jugo Slavia, Roumania, and Bulgaria. These are the only European (ex-Russian) countries which had any considerable net exports of wheat before or after the Great War (1). This in itself, would heighten the interest in a study of the quality of their wheat. But recent proposals at the World Wheat Conference at Rome, to make Europe (ex-Russia) self-sustaining as far as wheat was concerned, make this study doubly interesting.

TheDanube basin, as its name implies, is the area about the lower Danube in south-eastern Europe. Its area is(2) about 285,495 square miles, divided as follows: Roumania 113,856 square miles, Jugo-Slavia 95,942 square miles, Bulgaria 39,827 square miles, and Hungary 35,892 square miles. Wheat production in these states since the war amounted on an average (1924 to 1930) to 104.1 million bushels per annum, in Roumania, 78.8 million bushels in Jugo-Slavia, 75.1 million in Hungary, and 41.4 million in Bulgaria, or a total of 299.4 million bushels per annum in the Danube Basin. Of this amount produced, the average exports (1924-25 to 1929-30) were: Roumania 6 million bushels, Jugo-Slavia 10.4 million bushels, Hungary 22.2 million bushels and Bulgaria 1.3 million bushels, or a total average export from the Danube Basin of 40 million bushels or 13.3 per cent of the crop per annum.

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(1) International Year Book of Agricultural Statistics.1929-30. P. 265.

(2) Wheat Studies Vl. 5. P.190

Winter wheat is the main class of wheat cultivated in the Danube Basin (1). The only other classes grown are a small amount of spring bread wheat in northeastern Roumania, and some spring durum wheat in southern Bulgaria. The winter wheat is the kind known as hard red winter. The kernels are small, reddish and more or less vitreous. Unfortunately, an exact description of Danubian grains cannot be given because Technical Bulletin 197 did not include Roumania and Jugo-Slavia, and the grains from Hungary and Bulgaria that were tested, were mostly samples of unimportant varieties. However, with the information from this and other sources, we can form a sufficiently accurate opinion about the quality of Danubian wheat. The following tables describe the properties of some of the Bulgarian and Hungarian varieties of wheat(2).

Danubian Wheats: Description and Characteristics.

Reference No.	Samples Analyzed	Grown in	Class	Grade	Dockage %	Kernel Texture %	Test Weight per bushel Pounds	Damaged Kernels %	Foreign Material other than Dockage %
1	1	Bulgaria	Hard Red Winter	2 Hard Winter	.0	30.2	59.5	2.7	.0
2	3	"	Soft Red Winter	3 Red Winter	1.0	....	57.4	1.5	.8
3	2	"	Durum	2 and 3 amber durum	1.3	92.0	57.9	.5	.7
4	1	Hungary	Hard Red Winter	2 Hard Winter	.0	53.3	59.7	1.4	.0
5	2	"	Soft Red Winter	2 Red Winter	.0	....	60.0	1.8	.0

(1) Wheat Studies Vl. 5. P.232
(2) Tech. Bull. 197 pp. 105 et seq. and p. 126

Danubian Wheats: Milling Properties and Certain Chemical Characteristics.

Reference No.	1	2	3	4	5
Test Weight per bushel	61.7	59.5	59.5	61.8	61.3
Screenings and scourings removed %	2.4	4.6	6.2	1.1	2.2
Moisture content of wheat %	9.3	9.1	8.8	10.8	9.1
Flour yield basis cleaned and scoured %	72.7	69.7	70.3	72.6	73.1
Flour yield basis dockage free %	71.0	67.3	66.8	71.8	71.5
Wheat per barrel of flour.Pounds	263	277	279	265	261
Milling Texture.	Semi-Hard	Soft	Very Hard	Semi-Hard	Soft
Texture of flour.	Soft	Soft	G(1)	Soft	Soft
Color of flour.visual	White	White	C(1)	White	White
Color of flour gazoline value	1.10	1.61	1.85	1.51	1.38
Ash in flour%	.41	.48	.83	.49	.48
Acidity of wheat as pH	6.51	6.57	6.66	6.57	6.45
Acidity of wheat as lactic acid %	.342	.280	.240	.268	.408
Crude protein in wheat %	10.49	9.54	12.06	10.52	10.37
" flour %	9.16	8.37	11.57	9.87	9.09
Gluten quality index	2.02	2.38	2.64	1.88	2.16

(1) G - Granular C - Creamy

Danubian Wheats: Baking Properties.

Reference No.	1	2	3	4	5
Fermentation time. Min.	112	117	140	120	114
Proofing time. Min.	65	73	62	68	61
Water absorption of flour %	52.2	50.0	61.9	56.6	55.0
Volume of loaf. cc.	1,990	1,940	1,850	1,910	1,755
Weight of loaf. Grams.	480	480	512	501	497
Color of crumb.Score	89	81	84	87	80
Grain of crumb.Score	90	87	90	80	73
Texture of crumb.	Good	Fair	E(1)	FC(1)	Poor
Shade of color of crumb	C(1)	C	VC(1)	C	C
Color of crust	LB(1)	Pale	B(1)	LB	Pale
Break and shred	Fair	Fair	Poor	Fair	Poor
Bread per barrel of flour.Pounds	277	277	295	289	287

With regard to milling quality, the results obtained from Danubian wheats were satisfactory. The wheats had a fairly high test weight per bushel, and yielded a high percentage of flour. However, the baking results were poor. The Bulgarian flour had a short fermentation time and a low percentage of water absorption. It produced a loaf that had a small volume, and the amount of bread per barrel of flour was also very low. While the

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(1) E-Excellent FC-Fair Crumbly C-Creamy VC-Very Creamy LB-Light Brown B-Brown

Hungarian flour was better, it also produced a dough that had a short fermentation time, and a loaf of small volume, ppor color and coarse texture. The Bulgarian durums however gave very good results, and the two samples tested ranked very little below United States durum in milling and baking quality. Kent-Jones is also of the opinion that Hungarian wheats are lacking in strength. He says (1) :

> "They (flours from Hungarian wheat) were.... rather soft and runny. Their gassing powers were particularly poor....There are possibly other Hungarian wheats of greater strength than those the author has examined."

On the other hand, Percival (2) describes the variety T.erythrospermum, to which Banat (which is widely grown in Hungary and Roumania) belongs, as follows:

> "With the exception of one or two prolific, bearded, squarehead wheats they give poor yields of grain, although the baking quality of their flour is generally excellent."

As the great wheat fields of Jugo-Slavia and Roumania are adjacent to those of Hungary and Bulgaria, the properties of the wheats of the former two countries approximate closely to those of the latter (3). One of the recent Studies published by Stanford University, that deals with the Danube Basin, quotes two thorough investigations made into the quality of Danubian wheats. As these studies covered the whole of pre-war Hungary and Roumania,

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(1) Op. cit. P.39
(2) Op. cit. p.278
(3) Wheat Studies Vl. 5. p.225

they include practically the entire Danube Basin, with the exception of Bulgaria. These studies show that the quality of the wheat both countries is very similar. Roumanian wheats have a lower protein content than Hungarian wheats. As Jugo-Slavia now includes some provinces that formerly produced the best Hungarian grain, Jugo-Slavian grain is now probably as good as the Hungarian. One undesirable characteristic of Danubian wheat cargoes is the high percentage of foreign seeds, especially rye, which reduces still further the strength of the flour milled. This is more true of wheat coming from Roumania and Bulgaria where the land is held largely by the peasants who use ancient threshing methods. One more quotation about Danubian wheats must be given (1):

> "They resemble the American hard winter wheats grown in Kansas and Nebraska, and, if well cleaned and uniformly graded, are capably of competing with these on a quality basis on European markets."

In view of this contradictory evidence, I believe it is probably wiser to agree with those authorities who had more experience in dealing with commercial varieties of Danubian wheats. We may therefore conclude that Danubian wheats are not strong wheats, but are probably good filling wheats.

Although Russia has shown little activity as an exporter of wheat since the war, her dramatic re-entry into the export

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(1) Wheat Studies Vl. 5. p.233

market in 1930, has shown that she has now passed from being a potential to an actual competitor for the international grain markets. Wheat production is carried on in southern and central Russia. The area under cultivation extends from the Ukraine into Asiatic Russia. The eastern limits of wheat production seem to have been determined by lack of transportation facilities rather than climatic conditions (1). During the period 1925-1928, 40% of the Russian wheat produced was grown in Asia. Russia produces spring and winter bread wheats, and durum wheats. Russian wheats are noteworthy for their consistently high protein content. The following tables summarize the results obtained from testing samples of Russian wheats at Washington (2).

Russian Wheats: Description and Characteristics.

Reference No.	Samples Analyzed	Class	Grade	Dockage %	Kernel Texture %	Test Weight per bushel Pounds	Damaged Kernels %	Foreign Material other than Dockage %
1	5	Hard Red Spring	3 Dark N. Spring	.2	86.2	57.4	.4	0.1
2	11	Hard Red Winter	1 Dark Hard Winter	.1	89.1	60.5	1.2	.0
3	9	Soft Red Winter	2 Red Winter	.1	....	58.2	1.6	.0
4	13	Durum	2 Amber Durum	.1	94.7	59.9	1.3	.0
5	2	White	2 Soft White	.3	64.5	59.6	.7	.0

(1) Economic Geography Vol.1. 1925. p.45
(2) Tech. Bull. 197 p.152 et seq.

Russian Wheats: Milling Properties and Certain Chemical Characteristics.

Reference No.	1	2	3	4	5
Test Weight per bushel	58.7	62.0	59.5	60.1	60.9
Screenings and scourings removed %	2.5	1.7	2.4	2.7	2.1
Moisture content of wheat %	10.1	10.7	10.3	10.5	11.4
Flour yield basis cleaned and scoured %	68.3	73.5	70.0	71.5	74.1
Flour yield basis dockage free %	67.1	72.3	68.4	69.5	72.6
Wheat per barrel of flour.Pounds	284	265	277	273	264
Milling Texture	Hard	Hard	Soft	Hard	Semi-Hard
Texture of flour	G(1)	G	Soft	G	Soft
Color of flour.visual	SC(1)	SC	C(1)	C	SC
Color of flour gasoline value	1.52	1.55	1.88	1.62	1.53
Ash in flour%	.57	.54	.49	.80	.56
Acidity of wheat as pH	6.58	6.58	6.56	6.55	6.52
Acidity of wheat as lactic acid %	.294	.285	.266	.289	.357
Crude protein in wheat %	14.51	13.00	12.44	15.31	10.69
" flour %	13.47	12.25	11.42	14.65	9.85
Gluten quality index	2.04	2.11	2.07	2.97	2.13

(1) G-Granular SC-Slightly Creamy C-Creamy

Russian Wheats: Baking Properties.

Reference No.	1(1)	2	3	4	5
Fermentation time. Min.	135	144	110	140	127
Proofing time. Min.	62	61	58	62	63
Water absorption of flour %	57.5	57.7	54.0	62.7	56.9
Volume of loaf. cc.	2,280	1,960	2,100	2,140	2,115
Weight of loaf. Grams	499	501	496	518	498
Color of crumb. Score	82	81	80	80	83
Grain of crumb. Score	82	67	66	89	88
Texture of crumb	Fair	FC(2)	FC	VG(2)	Good
Shade of color of crumb	C(2)	VC(2)	VC	VC	C
Color of crust	LB(2)	B(2)	LB	B	LB
Break and shred	Fair	Fair	Fair	Poor	Fair
Bread per barrel of flour.Pounds	288	289	286	299	287

The milling and baking qualities of the hard red spring wheat were very unsatisfactory. 284 pounds of wheat were required to produce a barrel of flour. The ash content was high, and although the flour had a high protein content, it produced a bread of inferior quality. Although one very poor sample was excluded, the texture, color, break and shred, and pounds per barrel of flour, were still much inferior to the results obtained from American wheats. It must be noted however that all the samples of Russian

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(1) Excluding one sample that gave very poor baking results.

(2) FC-Fair crumbly VG-Very Good C-Creamy VC-Very creamy LB-Light Brown B-Brown.

spring wheats came from the Ukraine and are not necessarily representative of the quality of spring wheats grown further east.

The hard red winter wheat gave good milling results. The test weight per bushel, flour yield, and protein content were all high, and it required only 265 pounds of wheat to produce a barrel of flour. The baking quality of the hard red winter wheat was not good. The volume of loaf was small, and the texture and break and shred were unsatisfactory. The soft red winter wheat gave, as was to be expected, results inferior to those of the hard red winter. This wheat was also characterized by having a high protein content and yielding a bread that had inferior baking qualities.

Durum wheat gave the best results on being tested. All the samples had a high protein content, and gave uniformly high results from all the tests, which compared very favourably with the results obtained from American durums. In baking properties the Russian durum gave better results than the American; the former had a longer fermentation time and gave more bread per barrel of flour than the latter. The two white wheats tested were also above the average for their class of wheat.

If we consider the bread wheats only, Russian wheat gave unsatisfactory results. The most conspicuous feature about Russian wheats is their uniformly high protein content, and the unsatisfactory baking properties often displayed by samples received. The

lack of correspondence between these two characteristics is the great fault of Russian wheats; and it is the one usually remarked upon by observers. Thus Kent-Jones (1) says:

> "Russian wheats....are:fairly glutinous, contain 10.5 to 13.5 per cent protein, although the gluten is of a floury nature. They lack stability. They usually weigh 58 to 62 pounds (imperial) to the bushel. Rye is the important impurity, and unless removed before milling, tends to accentuate the lack of stability. The north Russian wheats shipped from Baltic ports generally have a higher moisture content and yield flour of less stability than south Russian wheats."

India, like Russia, has played an unimportant part in the international trade in wheat since the war (2). However, unlike Russia, she seems destined not to recover her position as a wheat exporting country, but to become a wheat importing country in the not too remote future. Bread wheats form the predominating part of the wheat harvest, and most of the Indian wheats are fall sown. The following tables show the characteristics of typical Indian wheats (3).

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(1) Op. cit. p.37
(2) Wheat Studies Vll. 2. p.173
(3) Tech.Bull. 197 p.187 et seq.

Indian Wheats: Description and Characteristics.

Reference No.	Samples Analyzed	Class	Grade	Dockage %	Kernel Texture %	Test Weight per bushel Pounds	Damaged Kernels %	Foreign Material other than Dockage %
1	14	Hard White	1 Hard White	.1	89.1	62.6	.5	0.0
2	7	Soft White	1 Soft White	.0	50.8	62.2	1.0	.0
3	4	Soft Red Winter	1 Western Red	.0	....	62.3	.1	.1
4	2	Durum	1 Durum	.0	68.8	60.8	.1	.0

Indian Wheats: Milling Properties and Certain Chemical Characteristics.

Reference No.	1	2	3	4
Test weight per bushel	63.3	63.4	63.7	61.7
Screenings and scourings removed %	1.7	1.3	1.4	3.7
Moisture content of wheat %	9.8	10.2	9.9	9.9
Flour yield basis cleaned and scoured %	74.1	74.6	72.4	75.5
Flour yield basis dockage free %	72.8	74.0	71.5	72.7
Wheat per barrel of flour. Pounds	258	255	264	259
Milling Texture.	Hard	Hard	Semi-Hard	Very Hard
Texture of flour.	G(1)	G	Soft	G

(1) G-Granular

Indian Wheats: Milling Properties and Certain Chemical Characteristics (Contimued).

Reference No.	1	2	3	4
Color of flour.visual	SC((1)	SC	SC	C(1)
Color of flour gasoline value	1.46	1.60	1.57	1.05
Ash in flour%	.64	.65	.56	.82
Acidity of wheat as pH	(2) 6.60	(2) 6.63	(3)	6.64
Acidity of wheat as lactic acid %	(2) .232	.289	(3)	.202
Crude protein in wheat %	10.91	8.71	9.49	10.01
" flour %	10.06	7.95	8.79	9.23
Glutan quality index	(2) 3.08	(2) 2.90	(3)	3.97

Indian Wheats: Baking Properties.

Reference No.	1	2	3	4
Fermentation time. Min.	143	145	131	164
Proofing time. Min.	67	70	62	75
Water absorption of flour %	65.4	63.0	62.6	65.0
Volume of loaf. cc.	1,740	1,620	1,620	1,680
Weight of loaf. Grams.	521	516	513	515
Color of crumb. Score	83	81	76	78
Grain of crumb. Score	78	75	69	80
Texture of crumb	PC(4)	PC	PC	Poor
Shade of color of crumb	C	C	VC(4)	VCG(4)

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(1) SC-Slightly Creamy C-Creamy
(2) Average of samples tested.
(3) Not given
(4) PC-Poor Crumbly VC-Very Creamy VCG-Very Creamy Gray.

Indian Wheats: Baking Properties (Continued).

Reference No.	1	2	3	4
Color of crust	B(1)	LB(1)	LB	LB
Break and shred	Poor	VP(1)	VP	VP
Bread per barrel of flour.Pounds	300	297	296	297

The outstanding feature of the Indian wheats is their excellent milling quality coupled with their inferior baking quality. The wheats had a high test weight per bushel, and their yield of flour was greater than any other sample of the same class tested at Washington. Their protein content, however, was low, the volume of loaf was small, and the bread produced was of poor texture and break and shred. Kent-Jones says (2):

> "while not strong in the usually accepted sense, most Indian wheats were able to impart to a blend that stability which is so often desired...The real strength of Indian wheats can be seen when mixed with Russian wheats...To get the best out of Indian wheats...they should be conditioned, if possible, so that the proteolytic enzymes are encouraged...Their protein is too coagulated."

We have now considered the properties of the wheats grown and exported by the major exporting countries of the world. We have seen that there are so many varieties of wheat grown and that there are so many properties in which wheats can differ that an exact comparison between the qualities of all the wheat grown in one

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(1) B-Brown LB-Light Brown VP-Very Poor
(2) Op. cit. p.36

country and that grown in another is a difficult matter. However, there are certain conclusions that can be drawn safely from the facts presented above.

There are two main varieties of wheat grown on a large scale, bread wheats and durum wheats. The first group includes hard and soft red wheats and white wheats. They are used, as their name implies, mainly in the baking of bread; and, as they thus compete with each other to a greater or less extent, can be compared to each other. Durum wheats, that are used mainly to make macaroni and alimentary pastes, may be considered by themselves.

All the countries considered grow durum wheat; but only Canada, the United States, Russia and the Danube Basin, are in a position to export large quantities of this variety. Danubian durum is somewhat deficient in baking strength and therefore slightly inferior to that of the other three countries. The latter produce durum wheat of good quality. Canadian and American durum wheats are of about the same quality. Russian durum shows a distinct superiority, over the Canadian and United States durums. Before leaving the durums we may notice that there seems to be a growing tendency to use durums as filler wheats in milling flour. The opinion on this subject held by British millers is expressed by Kent-Jones (1). He says:

> "Some years ago durums were considered exceptionally weak, and were very much

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(1) Op. cit. p.31

> disliked. This was probably because they had not been sufficiently mellowed down and conditioned. Now that the method for dealing with them is better known they are no longer considered as exceptionally weak. Being fairly dry and requiring much water, they are considered to be profitable wheats."

Of the bread wheats grown, hard red spring has the most desirable milling and baking qualities. Among the exporting countries, the important producers of hard red spring wheat are Canada, the United States and Russia. Canadian hard red spring wheat is distinctly superior to United States hard red spring in milling quality and slightly superior in baking quality. Russian spring wheat seems to be inferior in milling and baking quality to that of Canada and the United States.

Hard red winter wheat is grown in large quantities in the United States, Russia, Argentina and the Danube Basin. Canadian hard red spring compared with the hard red winter of these countries as follows: the Canadian wheat was superior in all milling properties except flour yield where Russian wheat ranked slightly higher, and pounds of wheat per barrel of flour in which Danubian, Russian and United States wheat were superior to it in the order given. In baking quality Canadian spring wheat was superior to the winter wheat of other countries in all respects except volume of loaf where it was slightly exceeded by Argentine and United States wheat. Among themselves the hard red winter wheats compared as follows. That of the United States exceeded those of the other countries in both milling and baking qualities.

The wheat of Argentina was of fair quality. The Russian wheat was somewhat lacking in baking strength, while the Danubian wheat had less strength than the Russian. Soft red winter wheat is grown in important quantities in the United States, Russia and the lower Danube Basin. While soft red winter wheat usually shows satisfactory milling qualities it is deficient in baking strength. Even that of the United States which proved itself to be superior to the soft red winter wheats of other countries had a low fermentation time, water absorption, and yield of bread per barrel of flour. Of the Russian and Danubian soft red winter wheats the Russian showed a slightly greater baking strength.

Although hard white wheats are almost always superior to soft white wheats, white is generally grouped as one class. India, Australia, and the United States, in the order named, produce most of the white wheat grown in the world. Indian white wheat has excellent milling properties. The amount of wheat needed to produce a barrel of flour, 257 pounds, is less than that of any other kind of wheat. Australian wheat is second in milling properties; its properties are not as outstanding as those of the Indian wheat. United States white wheat is slightly inferior to Australian. Unfortunately, the baking strength of Indian wheat is somewhat low; as stated above, Indian wheat is known more for its stability than its strength. The strength of white wheat from Australia and the United States is about the same. It is somewhat stronger than United States soft red winter wheat.

Summary of Milling and Baking Qualities of Wheats of Exporting Countries.

Class of Wheat and Country where grown	No. of Samples	Test Weight per Bushel Pounds	Flour Yield %	Wheat per barrel of flour Pounds	Crude Protein in Wheat %	Crude Protein in Flour %	Ash in Flour %	Color of flour	Fermentation time Min.	Water Absorption of flour %	Volume of loaf cc.	Color of crumb score	Grain of crumb score	Texture of crumb	Bread per barrel of flour Pounds
Hard Red Spring.															
Canada(1)	135	60.9	69.6	276	13.14	12.38	.48	SC(2)	141	60.9	2110	87	89	Good	293
Russia	5	57.4	66.9	284	14.51	13.48	.57	W(2)	129	56.5	2166	80	69	Fair	288
United States	15	59.5	68.8	277	12.77	11.98	.50	SC	147	58.3	2162	87	91	Good	289
Hard Red Winter.															
Argentina	31	56.1	64.5	298	11.00	10.07	.49	SC	127	55.8	2187	87	91	Good	286
Danube Basin	2	59.6	71.4	264	10.51	9.52	.45	W	116	54.4	1950	88	85	Good	283
Russia	11	60.5	72.3	265	13.00	12.25	.54	SC	142	57.7	1963	81	65	Fair	289
United States	67	60.1	70.0	271	10.87	9.96	.52	W	138	58.0	2145	87	91	Good	289
Soft Red Winter.															
Danube Basin	5	58.4	69.1	271	9.87	8.66	.50	W	116	52.4	1865	81	83	Fair	281
Russia	9	58.2	68.4	277	12.44	11.30	.57	SC	110	54.0	2006	80	65	Fair	286
United States	63	59.9	68.8	276	10.24	9.15	.48	W	114	53.5	2133	88	88	Fair	282
Durum.															
Bulgaria	2	57.8	66.8	278	12.06	11.57	.83	C(2)	140	61.9	1870	84	90	E(2)	294
Canada	2	62.0	71.2	268	11.76	11.32	.66	C	130	59.4	2010	84	90	VG(2)	292
Russia	13	60.0	69.5	273	15.28	14.75	.80	C	140	62.7	2142	80	89	E	299
United States	11	61.1	70.4	274	12.02	11.27	.67	C	136	60.7	2029	84	89	VG	295

(1) Average of 135 samples composed of:

No.	1	Manitoba	Northern	31
"	1	"	" Tough	3
"	2	"	"	33
"	"	"	"	12
"	3	"	"	28
"	"	"	"	3
"	4	"	"	14
"	5	"	"	7
"	6	"	"	3
Feed Wheat				1
Total				135

(2) SC-Slightly Creamy W-White C-Creamy E-Excellent
VG-Very Good.

Summary of Milling and Baking Qualities of Wheats of Exporting Countries (Continued).

Class of Wheat and Country Where Grown	No. of Samples	Test Weight per Bushel Pounds	Flour Yield %	Wheat per Barrel of flour Pounds	Crude Protein in Wheat %	Crude Protein in Wheat %	Ash in Flour %	Color of flour	Fermentation time Min.	Water Absorption of flour %	Volume of loaf cc.	Color of crumb score	Grain of crumb score	Texture of crumb	Bread per barrel of flour Pounds
White															
Australia	12	60.6	71.5	269	10.27	9.32	.50	White	117	54.8	1,982	87	88	Good	286
India	21	62.5	73.2	257	10.17	9.41	.64	SC(1)	144	64.6	1,711	82	77	Poor	299
Russia	2	59.6	72.6	264	10.64	9.85	.56	C(1)	126	56.4	2,105	83	88	Good	287
United States	46	60.5	68.8	276	10.96	9.81	.51	White	115	54.7	2,038	88	87	Fair	285

(1) SC-Slightly Creamy C-Creamy

According to this table Canada produces a wheat whose baking strength is superior to that of any wheat produced by competing countries except possibly United States hard red spring. This does not necessarily imply that Canada has an advantage in the international trade in wheat. For unless importing countries need the added strength in Canadian wheat and are willing to pay for it, it will not help Canada sell her wheat.

The next problem, therefore, is to determine the quality of the wheat of importing countries, and see to what extent these countries need strong wheat to mix with the wheat domestically grown. This will be discussed in the following chapter.

A Comparison of the Quality of Wheat Grown in Important Areas of Production.(Continued)

1.b Wheat Importing Countries

The British Isles import more wheat than any other country in the world. Their imports averaged over 225 million bushels per annum from 1924 to 1929.(1) Their domestic production for the same period was about 53 million bushels. That is to say, the British Isles import approximately 80 per cent of their total wheat consumption. It would seem, therefore, that although the British Isles may need to import some strong wheat to blend with their domestic wheat, by far the greater part of their imports would be wheat of merely sufficient strength to produce satisfactory flour with little or no help from strong flour. Wheats grown in the British Isles are mainly soft red winter wheats. Red spring and white winter wheats are also grown. The following table shows the properties of samples of the wheats grown there. (2)

British Wheat: Description and Characteristics

Reference No.	Samples Analyzed	Class	Grade	Dockage %	Kernel Texture %	Test Weight per Bushel Pounds	Damaged Kernels %	Foreign Material Other than Dockage %
1	3	Hard Red Spring	1 Red spring	0.0	14.4	61.3	.6	0.0
2	14	Soft red" Winter	3 red Winter	.1	"	60.0	4.9	.1
3	5	White	3 Soft White	.1	28.3	60.1	4.4	.0

(1) Wheat Studies Pp. 167 and 173
(2) Tech.Bull.197, p. 111

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British Wheat : Milling Properties and. Certain Chemical Characteristics

Ref.No.	1	2	3			
Test Weight lbs.	62.2	61.0	61.2			
Screenings and scourings removed. %	1.5	2.1	2.3			
Mixture %	8.7	10.0	9.9			
Flour yield(S.&.S)	72.8	71.4	72.7	;(D.F.)71.8	69.9	71.2
Wheat per barrel flour Lbs.	258	271	264			
Milling characteristics	Soft	Soft	Soft			
Texture of Flour	Soft	very Soft	Soft			
Colour Vis.	S.C.	White	White			
Gasoline Value	1.36	1.08	1.32			
Ash %	.50	.53	.50			
Acidity P.H.	6.56	6.48	6.48			
Lactic Acid %	.374	.399	.352			
Crude Protein in wheat	9.74	9.20	8.84			
in flour	8.98	8.17	7.92			
Gluten Quality Index	2.19	2.32	2.35			

British Wheat: Baking Properties

Reference No.	1	2	3
Fermentation time. Min.	98	99	94
Proofing time. Min.	49	50	49
Water Absorption of flour %	52.2	53.1	52.2
Volume of loaf cc.	1,620	1600	1,660
Weight of loaf grams.	494	495	493
Colour of crumb score	76	78	81
Grain of Crumb score	60	55	45
Text.of crumb	Fair,crumbly;	poor crumbly;	Crumbly
Shade of color of crumb	creamy	creamy gray	creamy
Color of crust	Pale	Light brown	Pale
Break and shred	Poor	Poor	Poor
Bread per barrel of flour. Pounds	285	285	284

Note:- In this chapter flour yield is given as a percentage of
(a) Screened and Scoured wheat.
(b) Dockage free wheat.

3b. It will be seen from the tables that while the milling properties of British wheats are satisfactory, the wheats are very deficient in baking strength. Only one variety of wheat, yeoman, a soft red winter wheat, has sufficient strength to produce satisfactory flour. This variety is widely grown in south and east England. It follows therefore, that most of the 53 million bushels grown in the British Isles must be blended with strong wheats to produce a flour that will be acceptable to British bakers.

ITALY is the second largest importer of wheat in the world. Her imports averaged over 80 million bushels a year, during the period 1924 to 1929. Her domestic crop for the same period was about 211 million bushels. Thus Italy imports roughly one quarter of her total domestic requirements of wheat. Although the Italians are known as a macaroni-eating people, durum wheat, which is so well suited for the manufacture of macaroni, forms only about 20 or 25 per cent of the total crop of wheat. (3) Durum is grown mostly in the southern part of the country and in Sicily. The remainder of the wheat grown is mostly bread wheat, soft red winter and some white winter wheat. Small amounts of poulard and Polish wheats are also grown.

Important milling and baking qualities of Italian wheats are given in the tables below:

Italian Wheats: Description and Characteristics

Reference No.	No. of Samples	Class	Grade	Dockage %	Kernel Texture %	Test wt. per bushel pounds	Damaged Kernels %	Foreign Material other than dockage %
1	3	Durum	2 amber Durum	.2	90.1	61.8	1.6	0.0

(3) Tech.Bull.197. P.131.

4b Italian Wheats: Description and Characteristics (Continued)

Reference No.	No. of samples	Class	Grade	Dockage %	Kernel Texture %	Test Weight per bushel pounds	Damaged kernels	Foreign Material other than dockage %
2	23	Soft red Winter	3 Red Winter	.0		58.2	1.3	.0
3	3	White	3 Soft White	.0	72.0	58.0	.2	.0

Italian Wheats: Milling Properties and Certain Chemical Characteristics

Reference No.	1	2	3
Test Weight	61.2	58.2	58.0
Screenings and Scourings	3.2	2.1	1.5
Moisture	10.5	10.9	10.8
Flour Yield			
S. & S.	70.9	70.8	71.1
D. F.	68.8	69.3	70.0
Wheat per barrel	275	275	271
Milling Characteristics	Very Hard	Soft	Soft
Texture of Flour	Granular	Soft	Very Soft
Color of Flour Visual	Creamy	White	White
Gasoline Value	2.20	1.29	1.29
Ash in flour	.85	.50	.48
Acidity PH	6.55	6.54	6.58
Lactic Acid	.319	.333	.310
Crude Protein in Wheat	11.41	11.18	10.25
in Flour	10.57	10.16	9.50
Gluten Quality Index	2.96	2.06	2.25

Italian Wheats: Baking Properties

Reference No.	1	2	3
Fermentation Time	121	106	107
Proofing Time	52	54	53
Water Absorption of Flour	64.8	53.0	52.2
Volume of Loaf	1,620	1,769	1,727
Color of Crumb	75	81	85

5b Italian Wheats: Baking Properties
(Continued)

Grain of Crumb	57	54	70
Texture	Fair	Poor	Poor
Shade	very,very creamy	Creamy	Creamy
Color	Brown	Light brown	Light Brown
Break and Shred	Poor	Poor	Poor
Bread per barrel Pounds	305	285	282

The durum wheats showed satisfactory milling qualities, although their protein content was low. This lack of protein showed itself in the weakness of the flour, which produced a loaf with a very small volume and inferior texture. The average milling and baking quality of the red and white wheats were about the same. Good yields of flour were obtained, but the flour was lacking in strength. The volume of loaf and water absorption was low, and the bread was of inferior texture, and break and shred. It is therefore evident that while Italian wheat gives satisfactory results when milled, there is very little domesticaly grown wheat that does not need to be strengthened before it can produce good flour.

Germany is another country that imports large quantities of wheat. She imported an average of 79 million bushels of wheat during the years 1924-25 to 1928-29.(4). During the same period, she grew domestically some 113 million bushels of wheat. Thus about 40 per cent of the wheat consumed in Germany is imported from abroad. German wheat is mainly soft red winter wheat. Some spring wheat is grown in the Northern districts, the amount depending on the climatic conditions. The following tables describe the properties of German wheats analyzed. (5)

(4) Wheat studies V112 pp. 267 and 273
(5(Tech.Bull 197 p.120

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German Wheats: Description and Characteristics

Reference No.	No. of samples	Class	Grade	Dockage %	Test Weight per Bushel Pounds	Kernel Texture %	Damaged Kernels %	Foreign Material other than Dockage %
1	2	Hard Red Spring	3 darker Northern Spring	.1	94.6	57.6	3.5	.0
2	4	Soft Red Winter	3 Red Winter	.0		57.2	4.2	.0

German Wheats : Milling Properties and Certain Chemical Characteristics

Reference No.	1	2
Test Weight	59.9	58.8
Moisture	11.5	10.9
Flour Yield		
Screenings and Scourings	72.2	71.3
D.F.	70.8	69.6
Wheat per barrel	271	273
Milling Characteristics	Hard	Soft
Texture of flour	Granular	Soft
Color:		
Visual	White	Slightly Creamy
Gasoline	1.22	1.91
Ash in flour	.55	.51
Acidity PH	6.38	6.49
Lactic Acid	.527	.413
Crude Protein		
in Wheat	13.79	9.68
in Flour	12.55	8.57
Gluten Quality Index	2.04	2.05

German Wheats: Baking Properties

Reference No.	1	2
Fermentation Time	140	133
Proofing Time	47	60
Water Absorption	64.1	54.6
Volume of Loaf	1,870	1,755
Weight of Loaf	512	490
Colour of Crumb	86	82
Grain of Crumb	88	79

7B German Wheats: Baking Properties(Continued)

Texture of Crumb	Fair	Very Poor
Shade of color of crumb	Light creamy	very creamy
Color of Crust	Brown	Light Brown
Break and Shred	Good	Very Poor
Bread per barrel of flour.Pounds	295	282

The German wheats displayed good milling properties. Their protein content was very high (the average for soft red winter wheats shown in the table was lowered by one poor sample). They were, however, almost all deficient in baking strength. The volume of loaf was rather small and the texture and bread and shred were unsatisfactory in the case of most of the samples. The United States Bulletin "Milling and Baking Qualities of World Wheats" states,(6) " As far as baking performance is concerned, German Wheats resemble in a marked degree English-grown wheat". In other words, a large proportion of the German wheat is not of sufficient strength by itself and needs to be strengthened by admixtures of imported wheats.

Although France imported less than 5 million bushels of wheat during the crop year 1929-30, this can hardly be regarded as a normal or permanent level of imports for that country. Her average net imports for the period 1924-25 to 1928-29,(7) some 46 million bushels, rank her as fourth among the wheat importing countries of the world. Domestic production of wheat in France averaged 280 million bushels for the same period. That is, France imported about 14 per cent of the wheat consumed in the country. Unfortunately, analyses of French wheat, similar to those of wheats of other countries are not available, and so an accurate

(6) Ibid P 119
(7) Wheat Studies Vll 2 P 167 and 173

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comparison can not be made. However, the following facts enable us to obtain some idea of the quality of French wheat. A.H.Bailey (8) cites the results of tests made by Arpin and Pecaud in 1923. He says, "Twenty of the 45 samples contained between 8.00 and 10.00 per cent of gluten, while only 5 contained in excess of 10.00 per cent. All but one of the 45 scored lower in total points than did the Australian, Plata, and Hard Winter wheats with which they were compared." The points were assigned on the basis of "the percentage and characteristics of the gluten and the qualities of loaves baked from a 60 per cent flour". I have learned through conversation with a French milling engineer that although a great variety of wheats is grown throughout France, they are all bread wheats (triticum vulgare), and would be classed as soft wheat. The French wheats are universally admitted to be weak wheats. We have further proof of their weakness from the fact that French millers have protested vigorously against the recent government regulations compelling the millers to use a minimum of 90 per cent domestically grown wheat in their mill mixes. The following extracts from a French periodical (9) illustrate the same point: "Aussitôt après la guerre on a cherché surtout la quantité aux dépens de la qualité .... Le résultat fut atteint, grâce à des blés qui ,,,,, fournissent un rendement abondant ....(mais) sont peu riches en gluten." "Dans la pratique c'est surtout aux blés de Manitoba qu'on s'est adressé ....(pour) faire appel... aux blés de force." It is therefore evident that the French wheats are deficient in baking strength, and are accustomed to rely upon Manitoba to overcome this deficiency.

(8) The Chemistry of Wheat Flour

(9) L'Illustration 14 Mar.1931 p.317 Lecoq; Farines et Pains d'Hier et d'Aujourd'hui.

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Although Belgium is a small country geographically, it is the most densely populated country in Europe, and depends to a great extent on imports for its wheat supplies. Average imports (10) for the period 1924-25 to 1928-29 were over 40 million bushels per annum. The average amount of wheat grown in Belgium during the same period was about 15 million bushels per annum. She therefore imported some 73 per cent of her total wheat requirements. In the case of Belgium, therefore, as in the case of Great Britain, large imports of wheat are made annually irrespective of the quality of the domestic crop, and the amount that may be needed to be blended with the domestic crop must necessarily form a small part of the total imports.

Belgian wheat is generally fall sown. White wheat is grown extensively, and the rest is mostly soft red winter. The following tables give the properties of the Belgium wheats analyzed(11)

Belgian Wheats : Description and Characteristics

Reference No.	Samples Analyzed	Class	Grade	Dockage %	Kernel Texture %	Test Weight per bushel Pounds	Damaged Kernels %	Foreign Material other than Dockage %
1	3	Soft red Winter	2 Red Winter	2		58.6	2.9	.0
2	3	White	2 Soft White	.5	49.8	58.4	2.2	.0

Belgian Wheats: Milling Properties and Certain Chemical Characteristics.

Reference No.	1	2
Test Weight	59.2	59.0
Screenings and Scourings removed	3.0	3.0
Moisture	9.9	9.7

(10) Wheat Studies V11 2 Pp.167 and 173
(11) Tech.Bull.197 p.100

10B Belgian Wheats: Milling Properties(Continued)

Flour Yield		
S.S	71.0	71.0
D.F.	69.0	69.2
Wheat per barrel	273	271
Milling Character-istics	Soft	Soft
Texture of flour	Very Soft	Soft
Color of flour		
Visual	White	White
Gasoline	1.02	1.32
Ash in flour	.52	..54
Acidity PH	(Not Given)	(Not Given)
Lactic Acid	.380	.415
Crude Protein		
in wheat	9.09	8.64
in flour	8.31	7.51
Gluten Quality Index	(Not given)	(Not given)

BELGIAN WHEATS: Baking Properties

Reference No.	1	2
Fermentation Time	130	122
Proofing Time	49	50
Water Absorption	56.2	55.1
Volume of Loaf	1,625	1,595
Weight of Loaf	496	489
Color of Crumb	85	82
Grain of crumb	78	75
Texture of Crumb	very poor crumbly	Crumbly
Shade of Color	Creamy gray	Creamy
Color of Crust	Very Pale	Pale
Break and Shred	Very Poor	Poor
Bread per barrel of flour.Pounds	286	282

The Belgian wheats gave a good yield of flour but the flour produced had a low protein content. The flour was very deficient in baking strength. It produced loaves that had a small volume, were coarse in texture, and had a very poor break and shred, and a poor color. In short, Belgian wheats undoubtedly need to be blended with imported strong wheats to produce satisfactory bread.

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The Netherlands may also be considered as a wheat importing country of major importance. Her imports for the years 1924-25 to 1928-29 were about 29 million (12) bushels a year. Domestic production in the Netherlands averaged some 6 million bushels a year during the same period. The amount of wheat imported into the Netherlands was therefore, over 80 per cent of the total amount consumed; and, as in the case of Great Britain and Belgium, the amount imported would be influenced more by the quantity than the quality of the domestic crop. Netherlands wheat (13) is mostly soft white wheat of winter habit. Some spring wheat is grown in the north mostly when winter wheat could not be sown or has been killed by frost. The following tables show the characteristics of Netherlands Wheat. (14)

Netherlands Wheat: Description and Characteristics.

Reference No.	No. of samples	Class	Grade	Dockage %	Kernel Texture %	Test Weight per bushel Pounds	Damaged Kernels %	Foreign Material other than Dockage %
1	1	Hard Red Spring	3 red Spring	0	8.0	59.8	5.5	0
2	1	Soft Red Winter	3 Red Winter	1	---	57.9	.3	0
3	8	White	2 Soft White	o	39.9	58.3	1.9	0

(12) Wheat Studies V11 2 pp.167 and 173
(13) Tech.Bull.197 p.141
(14) Tech.Bull 197 p.143

12B Netherlands Wheat: Milling Properties and Certain Chemical Characteristics

Refenence No.	1	2	3
Test Weight	60.4	58.8	59.5
Screenings and Scourings removed	2.2	1.4	1.8
Moisture	10.4	9.5	10.4
Flour Yield			
Cleaned and scoured	72.5	71.8	71.9
D.F.	70.9	70.8	70.6
Wheat per bbl.flour	267	265	268
Milling Characteristics	Soft	Soft	Soft
Texture	Very "	very"	Soft
Color Visual	White	White	White
Gasoline	1.61	1.60	1.85
Ash in flour	.47	.54	.50
Acidity PH	6.52	6.53	6.54
Lactic Acid	.444	.454	.348
Crude Protein			
in Wheat	10.18	8.03	9.55
in Flour	9.28	7.44	8.66
Gluten Quality Index	2.14	2.33	2.16

Netherlands Wheat: Baking Properties

Reference No.	1	2	3
Fermentation Time	89	94	101
Proofing Time	47	46	49
Water Absorption	54.5	51.3	51.7
Volume of Loaf	1,640	1,580	1,670
Weight of Loaf	500	488	491
Color of Crumb	72	74	75
Grain of Crumb	34	32	34
Texture	Poor,crumbly;	poor crumbly;	Poor
Shade of Color	Creamy gray;	Creamy gray;	Creamy Gray
Color of Crust	Light Brown	Pale	Pale
Break and Shred	Poor	Poor	Poor
Bread per barrel of flour. Pounds	288	281	282

While Netherlands Wheat gave a good yield of flour, it was strikingly deficient in baking strength. The results as tabulated under baking strength, are uniformly poor throughout. As a consequence of this lack of strength, Netherlands wheat is used to a great extent at home or in adjacent countries where it is exported, in the manufacture of biscuits and similar goods where

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the small percentage and weakness of the protein is not so noticeable. U.S.Technical Bulletin No.197 states (15) "This weakness is apparently recognized by the millers of the Netherlands as they import 30,000,000 bushels of wheat from overseas for blending and mixing purposes". While some of the 30 million bushels is imported to be mixed with domestic wheats, most of it is undoubtedly imported to be milled into flour containing little or no endosperm of Netherland wheats.

The annual imports of Czecho-Slovakia from 1924-25 to 1928-29 include some 20 million bushels of wheat(16). As the Czecho-Slovakian domestic production of wheat for the same period was about 40 million bushels annually, the imports formed about one third of the wheat used in that country. The wheat grown in the country is mostly hard red winter (17). Hard red spring is also grown but in smaller quantities. Only two samples of Czecho-Slovakian wheat were analyzed at Washington. Their properties are given in the tables below.(18).

Czecho-Slovakian Wheats: Description and Characteristics.

Reference No.	No.of Samples	Class	Grade	Dockage%	Kernel Texture	Test weight	Damaged Kernels	Foreign Material %
1	1	Hard Red Spring	2 Darker Northern Spring	o	76.1	61.8	2.3	0
2	1	Hard Red Winter	1 Hard Winter	0	76.4	62.4	.4	0

(15) Ibid P.142
(16) Wheat Studies V11 2 pp.167 and 173
(17) Tech.Bull.197 p.107
(18) Ibid. p.108

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Czecho-Slovakian Wheats: Milling Properties and Certain Chemical Characteristics.

Reference No.	1	2
Test Weight	63.7	63.2
Screenings and Scourings Removed	1.1	.9
Moisture	10.5	10.0
Flour Yield		
S. and S.	77.2	73.7
D.F.	76.3	73.1
Wheat per barrel	248	260
Milling Characteristics	Hard	Semi-Hard
Texture	Granular	Soft
Color Visual		
Gasoline	Slightly creamy	Slightly Creamy
Ash in flour	.56	.52
Acidity PH	6.56	6.67
Lactic Acid	.304	.204
Crude Protein		
in Wheat	12.18	10.08
in Flour	11.66	9.29
Proteins Quality Index	2.05	2.39

Czecho-Slovakian Wheats -Baking Properties

Reference No.	1	2
Fermentation Time	127	97
Proofing Time	48	49
Water Absorption	59.3	54.8
Volume of Loaf	1,860	1,620
Weight of loaf	512	500
Color of Crumb	84	79
Grain of Crumb	52	42
Texture	Poor Crumbly	Poor
Shade of color	Creamy Gray	Creamy
Color of crust	Brown	Light Brown
Break and Shred	Poor	Poor
Bread per barrel Pounds	295	288

The Czecho-Slovakian wheats showed excellent milling properties. They yielded a high percentage of flour that had a moderate percentage of ash, and a fair amount of protein. They were noticeably low however, in baking strength. The flour had a low fermentation time, and produced a loaf of small volume and of poor texture. Thus the Czecho-Slovakian wheats also proved to be of good milling quality but definitely

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lacking in baking strength.

Greece imported an amount of wheat approximately equal to the amount imported by Czecho-Slovakia, namely, some 20 million bushels. (19). Domestic productions during this period, 1924-25 to 1928-29, averaged 11.5 million bushels or about 55 per cent of imports. Wheat grown in Greece is mostly of the winter habit. (20). A small amount of spring wheat is also grown. The varieties commonly grown are durum wheats and soft red and white winter wheats. The wheats described in the tables are the results of the analysis of three samples of durum wheat, and one mixed sample containing soft red and white wheat in the ratio of one to five respectively.

Grecian Wheats: Description and Characteristics.

Reference No.	No. of samples	Class	Grade	Dockage %	Kernel	Test Weight	Damaged Kernels %	Foreign Material other than Dockage %
1	3	Durum	2 amber	.3	70.9	59.1	o.3	.6
2	1	White	3 Mixed	.8	---	57.1	4.0	.1

Grecian Wheats: Milling Properties and Certain Chemical Characteristics

Reference No.	1	2
Test Weight	60.2	58.3
Moisture	11.0	10.6
Flour Yield S.&S.	72.7	72.7
D.F.	70.2	69.5
Wheat per barrel of flour	271	273
Milling Characteristics	Very Hard	Soft
Texture	Granular	Soft
Color Visual	Creamy	White
Gasoline	1.80	.78
Ash in Flour	.78	.47

(19) Wheat Studies Vll 2 p.p. 167 and 173
(20) Tech. Bull. 197 p. 123

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Grecian Wheats: Milling Properties and Certain Chemical Characteristics (Continued)

Acidity PH	6.63	6.63
Lactic Acid	.320	.328
Crude Protein		
in Wheat	11.62	12.13
in Flour	10.88	10.98
Gluten Quality Index	3.24	1.46

Grecian Wheats: Baking Properties

Reference No.	1	2
Fermentation Time	135	136
Proofing Time	57	57
Water Absorption	61.8	54.4
Volume of Loaf	1,540	1,880
Weight of loaf	513	496
Color of Crumb	70	86
Grain of Crumb	59	86
Texture	Poor	Poor, crumbly
Shade of Color	Very, very creamy	Light Creamy Gray
Color of Crust	Foxy Brown	Brown
Break and Shred	Very poor	Fair
Bread per barrel of flour; pounds	296	286

The samples from Greece were of average milling quality, and gave a good yield of flour. Their Baking quality was inferior. The durum produced a loaf of very small volume and poor texture and break and shred. Flour milled from sample number 2 produced a loaf with a small volume and a coarse textmre. In short, the samples displayed average milling qualities but were deficient in baking strength.

Switzerland is another European country that does not grow sufficient wheat for domestic consumption. During the period 1924-25 to 1928-29 her average imports of wheat were about 16 million bushels and her average domestic production was about 4 million bushels(21) That is, Switzerland imported some 80 per cent of the wheat consumed in that country.

(21) Wheat Studies Vll 2 pp.167 and 173

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About 95 per cent of the wheat grown in Switzerland is winter wheat (22). The Wheat is mostly of the soft red winter class. A small amount of club wheat is also grown. The samples tested showed the following properties.(23)

Swiss Wheats: Description and Characteristics

Reference No.	No. of samples	Class	Grade	Dockage %	Kernel %	Test weight per bushel pounds	Damaged Kernel %	Foreign material other than Dockage%
1	1	Hard Red Spring	1 Dark Northern Spring	0	82.8	59.1	2.0	0.0
2	8	Soft Red Winter	2 Red winter	0	----	60.4	1.3	0.0

Swiss Wheats: Milling Properties and Certain Chemical Characteristics

Reference No.	1	2
Test Weight	60.8	61.1
Screenings and scourings removed	1.9	1.9
Moisture	9.5	10.6
Flour S.and S.	70.9	71.7
D.F.	69.5	70.3
Wheat per barrel of flour	269	269
Milling Characteristics	Soft	Soft
Texture	Soft	Soft
Color Visual	White	Slightly Creamy
Gasoline	.91	1.64
Ash in Flour	.60	.52
Acidity PH	6.32	6.48
Lactic Acid	.480	.331
Protein in wheat	12.65	10.52
in flour	11.87	9.78
Gluten Quality Index	1.76	2.08

(22) Tech.Bull. p. 171
(23) Ibid. pp 172 and 173.

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Swiss Wheats: Baking Qualities

Reference No.	1	2
Fermentation Time	110	106
Proofing Time	56	49
Water Absorption	55.8	54.7
Volumeof Loaf	1,890	1,642
Weight of Loaf	503	501
Color of Crumb	80	76
Grain of Crumb	66	38
Texture	Fair,crumbly	Poor
Shade of color	Creamy	Very Creamy
Color of Crust	Brown	Light Brown
Break and Shred	Poor	Poor
Bread per barrel of flour	290	288

The Swiss wheats showed good milling properties. They gave a good yield of flour with a fair percentage of protein, and required only 269 pounds of wheat to produce a barrel of flour. However, they were low in baking qualities, especially the soft red winter wheat. The latter had a short fermentation time, a very small volume of loaf, and a poor texture and break and shred. In short, the Swiss wheats, like many other European wheats, had good milling properties, but were decidely lacking in strength.

Austria is the only other European country whose imports of wheat averaged over 10 million bushels annually from 1924-25 to 1928-29. (24). Her imports during this period were about 15.5 million bushels, and her domestic crop averaged some 11 million bushels, or 41 per cent of her total consumption per annum. The only positive information I could obtain about Austrian wheat was from Percival (25) He describes a form of the variety triticum lutescens, Gneisendorf which is grown in Austria. It is a semi-flinty, late-maturing red wheat, probably of winter origin,and resembles

(24)Wheat Studies Vll 2 pp.167 and 173
(25)J.Percival -The Wheat Plant p.295

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English White Straw Red and Danish wheats. Since the latter two are very weak wheats, we may safely conclude that Austrian wheat is not an exception to the general class of wheat found in central Europe, and is very probably lacking in baking strength.

The remaining countries in Europe import such small amounts of wheat, that it would not be very profitable to consider them separately. These countries are: the Scandinavian group, Norway, Sweden and Denmark, that imported an average of some 24 million bushels of wheat per annum from 1924-25 to 1928-29; the Iberian peninsula which raises very large amounts of wheat, but is practically self-sufficing with regard to wheat; and the post-war east-European states of Poland, Finland, Estonia, Latvia, and Lithuania, which imported a total of some 15 million bushels per annum during the period under consideration.

Of the Scandinavian countries, Norway imported most of her wheat, 7 million bushels and raised only 600,000 bushels domestically. Sweden imported 8 million bushels, and grew 13 million within the country. Denmark imported 9 million bushels, and grew 9 million domestically (26). The wheat grown in Norway is almost entirely hard red spring wheat. The Norwegian wheats showed good milling quality, but were very weak. The loaves baked had a small volume, poor color and a very coarse texture and grain of crumbs(27). In Sweden, both spring and winter wheat is grown. The spring wheat is of the hard red variety, while the winter wheat is also red, but is a soft wheat.

(26) S.U.W.S. Vll p.p.167 and 173
(27(Tech.Bull.197 p.145

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The spring wheat was superior to the winter in milling and baking quality, but both showed very poor baking quality, being decidedly inferior to the wheats of the same class grown in North America (28). Wheats grown in Denmark are winter wheats and belong mainly to the soft red class. Like many other European wheats, Danish wheat gave satisfactory milling results, but showed a marked lack of baking strength. This is borne out by the fact that most of the wheat grown in Denmark is not milled, but is used to feed livestock (29).

Poland grows about 55 million bushels annually and imports about 6.5 million bushels (30). Her imports formed some 12 per cent of her total consumption. Polish wheats are mostly fall sown bread wheats (31). Some durum and spring wheat is also grown. White wheat is the class most commonly grown, although Swedish red wheats are also popular. The winter wheats are soft wheats. Of the samples received at Washington, only one was a bread wheat of winter habit. This sample had a rather high test weight per bushel and gave a yield above the average for white wheat. The baking results were fairly good. The volume of loaf and yield of bread was low, but the loaf produced was of good grain and texture. Judging from this and from the fact that the "summers are almost always too wet for wheat culture" we may agree with the conclusion stated in Bulletin 197 that "it would appear that Polish wheats should be blended with imported wheat to regulate their baking quality".

(28) Tech.Bull 197 p.170
(29) Tech.Bull 197 p.109
(30) Wheat Studies Vll 2 pp.167 and 173
(31) Tech.Bull.197.p.148

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Finland imports most of her wheat. Her domestic production is about 1 million bushels, and her imports are about 5.5 million bushels (32). I could find no description of Finnish wheats and so they are omitted from this discussion. As they are grown so far north, they are probably spring wheat and probably resemble the Russian spring wheats described in the previous chapter.

Estonia produces about 1 million bushels of wheat annually, and imports an approximately equal amount. Both hard red spring and soft white winter varieties are grown. Latvia now produces over 2 million bushels of wheat and the amount produced is increasing steadily. Her imports average slightly less than 2 million bushels. Hard red spring and soft red winter wheats are usually grown in Latvia. Wheat production is also increasing in Lithuania. Over 10 million bushels were grown in 1930. The chief variety grown is soft white winter. Soft red winter is also grown. Lithuania is practically self sufficient as far as wheat is concerned. The wheats of the three countries were similar in their milling and baking properties. The samples showed average and above average milling qualities, but were all decidedly poor in baking quality. Bulletin 197 (33) states:" The wheats of Estonia are similar to those of Latvia, Lithuania, and Poland, in that they need extensive blending with stronger wheats to improve their baking quality".

(32) Wheat Studies Vll 2 pp.167 and 173
(33) Op.Cit.P.118

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Having now considered the wheat-importing countries within Europe, we may pass on to the ex-European countries. Of these, we need only consider China, Japan and the Union of South Africa, for the reasons enumerated elsewhere (34).

Since the war Japan's imports of wheat have increased enormously. Her imports now average (1924-25 to 1928-29) some 16.5 million bushels per annum (35). Japan's domestic production during the same period was about 38.5 million bushels each year. Imports into Japan were therefore 30 per cent of the total domestic consumption. Indigenous Japanese wheats are mostly red and white bread wheats of spring and winter habit (36). A small amount of durum and club wheat is also grown. The following tables describe the Japanese wheats tested (37)

Japanese Wheats: Description and Characteristics

Reference No.	No. of Samples	Class	Grade	Dockage %	Kernel Texture %	Test Weight per Bushel Pounds	Damaged Kernels %	Foreign Material other than dockage %
1	4	Hard Red Spring	2 Northern Spring	0	59.1	58.8	.9	0
2	2	Soft Red Winter	1 Red winter	0	----	60.4	.5	0
3	1	White	1 Hard White	0	97.8	62.9	.0	0
4	1	White	3 Soft White	0	67.6	61.1	4.9	0

Japanese Wheats: Milling Properties and Certain Chemical Characteristics

Reference No.	1	2	3	4
Test Weight	60.8	62.2	63.4	62.5
Screenings and Scourings removed	1.3	1.2	1.9	1.5
Moisture	11.7	12.5	11.5	9.8
Flour Yield Basis S & S	67.5	69.6	75.7	74.3
D.F.	66.6	68.8	74.3	73.3
Wheat per barrel flour	288	282	258	256

(34) Vide Infra P.
(35) Wheat Studies Vll 2,pp.167 and 173
(36) Tech.Bull. 197 p.197
(37) Ibid p. 198

23B Japanese Wheats: Milling Properties (Continued)

Milling Characteristics	Soft	Soft	Soft	Soft
Texture of Flour	Soft	Very "	Soft	Soft
Color Visual	White	S.C.*	White	White
Gasoline Value	1.41	1.71	1.15	1.21
Ash in Flour	.46	.46	.51	.60
Acidity of wheat PH	6.46	6.40	6.49	6.42
Lactic Acid	.342	.339	.344	.405
Crude Protein in				
Wheat	11.43	9.96	10.90	11.33
Flour	10.26	8.90	10.04	10.46
Gluten Quality Index	2.08	2.30	2.00	2.12

Japanese Wheats: Baking Qualities

Reference No.	1	2	3	3
Fermentation Time	112	124	107	107
Proffing Time	57	60	57	45
Water Absorption	53.8	55.6	51.0	54.4
Volume of Loaf	1,868	1,895	1,880	1,540
Weight of Loaf	494	500	494	498
Color of Crumb	86	84	84	72
Grain of Crumb	65	79	62	11
Texture of Crumb	Poor	Poor	Poor	Very Poor
Shade of color of crumb	Creamy	Creamy	Creamy	Creamy Gray
Color of Crust	Light Brown	Pale	Light Brown	Light Brown
Break and Shred	Poor	Poor	Poor	Poor
Bread per barrel of flour. Pounds	284	288	285	287

The results obtained from milling and baking Japanese wheats varied considerably. The white wheats gave a high yield of flour, while the yield of flour from the red spring and winter was somewhat below the average. The soft white wheat showed extremely poor baking quality. The baking quality of the other samples was not satisfactory. The loaves produced were rather small, and were poor in texture, grain, and color. On the whole, Japanese wheats should benefit considerably from being blended with imported strong wheats.

* S.C. - Slightly Creamy

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Due to the unsettled state of affairs in China, it is difficult to obtain information about that country. In the years 1928 and 1929, some 3,250,000 and 3,200,000 acres sown/wheat were harvested in Manchuria (38). The average crop for the years 1927 to 1929 inclusive was about 55 million bushels (39). Technical Bulletin 197 (40) quotes B.W.Whitlock of the Bureau of Agricultural Economics, who surveyed the wheat situation in the Orient in 1924, as follows:-

> "In China, soft red winter and white wheats predominate. The wheat of the Yangtze Valley is largely soft red winter wheat. As a rule, it is dirty, weevily, and heat damaged, and sells for about two-thirds of the price of imported wheat. The wheat of the Yellow River Valley and the Shantung peninsula is largely white wheat of a vitreous nature. It, too, is marketed in a dirty and damaged condtion.
>
> In Manchuria spring wheats predominate. They are of moderate strength, resembling wheat of the Pacific Northwest, but they are extremely dirty wheats and are often smutty; they mill into a flour of poor color and flavour. They often carry an earthy odor, and for this reason it is dangerous to use too high a proportion of Manchurian wheats in blending."

The Union of South Africa produced an average of some 8 million bushels of wheat per annum from 1926 to 1929 inclusive (41). During that period ~~per~~ imports averaged about 5.5 million bushels annually (42). Over 75 per cent of the indigenous wheat is grown in the Cape of Good Hope. The classes of wheat grown in the Union of South Africa correspond to North American Hard Red Spring, Hard White, and Soft Red Winter (43). The following tables describe the classes of wheat tested(44).

(38) International Yearbook of Agricultural Statistics.1929-30;P.144.
(39) Ibid p. 145
(40) Op. Cit. p.203.
(42) Ibid p.269
(43) Tech.Bull.197;p.183
(41) International Yearbook of Agricultural Statistics 1929-30 p.145.
(44) Ibid pp.184 et.seq.

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Union of South African Wheats: Description and Characteristics.

Reference No.	No. of Samples	Class	Grade	Dockage %	Kernel Texture %	Test Weight per bushel Pounds	Damaged Kernel %	Foreign material other than Dockage %
1	5	Hard Red Spring	1 Northern Spring	.8	71.2	62.3	3.1	.1
2	3	Soft Red Winter	1 Red Winter	.4	---	62.0	.5	.6
3	5	White	1 Hard White	.8	89.3	62.1	.5	.0

Union of South African Wheats: Milling Properties and Certain Chemical Characteristics

Reference No.	1	2	3
Test Weight per bushel	63.3	62.9	62.9
Screenings and Scourings removed	2.0	2.2	2.3
Moisture	11.5	11.5	11.5
Yield S.& S.	70.3	70.9	72.5
D.F.	69.4	69.8	71.6
Wheat per barrel of flour	276	275	268
Milling Characteristics;	Semi-hard	Soft	Semi-Hard
Texture of Flour	Soft	Soft	Soft
Color of Flour Visual	White	White	White
Gasoline Value	1.23	1.28	1.27
Ash in Flour	.55	.52	.53
Acidity PH	6.47	6.49	6.47
Lactic Acid	.272	.330	.356
Crude Protein in wheat	11.05	9.74	10.93
in Flour	10.26	8.95	10.23
Gluten Quality Index	2.25	2.36	2.39

Union of South African Wheats: Baking Properties

Reference No.	1	2	3
Fermentation Time	137	141	141
Proofing Time	67	67	61
Water Absorption	63.5	56.3	59.8
Volume of Loaf	1,828	1,770	1,810
Weight of Loaf	513	497	506
Color of Crumb	81	82	81
Grain of Crumb	81	81	78
Texture of Crumb	Poor	Poor	Poor

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Union of South African Wheats: Baking Properties (Cont'd)

Shade of Color of Crumb	Creamy	Creamy	Very Creamy
Color of Crust	Light Brown	Brown	Light Brown
Break and Shred	Very Poor	Very Poor	Very Poor
Bread per barrel of flour	296	287	291

The wheats of all classes were surprisingly uniform in their characteristics. They had a high test weight per bushel, add gave excellent milling results, yielding a high percentage of white flour with low ash content. The baking strength of all the wheats were distinctly lower than similar American wheats. The loaves produced were of small volume, and poor texture. Mixing with strong wheat would undoubtedly improve their baking quality.

We have now briefly examined the wheats produced in the more important wheat-importing countires, and are prepared to draw some conclusions from this survey. Before we do so, however, a brief comment on the statistical adequacy of the tables given above is necessary. Except in the case of Canada, and the United States, the number of samples from each country of each class of wheat tested, was in most cases, below ten, and very rarely exceeded twenty. The validity of drawing conclusions about an annual crop of millions of bushels, from so small a number of samples, is therefore very doubtful. We may overcome this objection if we present our conclusions, not as facts that have been proven, but as likely indications of the truth.

The most conspicuous feature of this survey is the uniform lack of baking strength among the wheats of the wheat-importing countries. Although the milling properties of the

wheats of these countries were usually quite satisfactory, they produced extremely little wheat that could be described as strong, and by far the greater part of their wheat was definitely lacking in baking strength. The reason for this prevalent lack of strength lies in the fact that the strength of wheat and yield per acre usually vary inversely to each other. On this point Percival (45) says:-

> " There is a strong positive correlation between mealiness and high grain yielding capacity in the race of breadwheats (T.Vulgare). Varieties possessing normally opaque grains are generally slow growing wheats with a long vegetative period and adopted for cultivation in humid climates or on irrigated land. On the other hand, those giving a high proportion of flinty grains produce less, grow and ripen more rapidly, and are met with chiefly in regions having a comparatively dry continental climate".

He goes on to say (46) "Although there are many exceptions, the "strong" wheats generally have red grains with hard "flinty" endosperm, the weaker types having paler red or white grains with opaque "chalky" endosperm".

It is thus evident why North America and eastern Russia with their continental climate produce a strong wheat with a low yield per acre; while the European and Asiatic wheat-importing countries, where the climate is more moist, and where a high yield per acre is usually held to be essential, produce weak wheats.

The relative importance of the lack of strength in the wheat of a country, depends on the habits and customs of its inhabitants. If these have become accustomed to eating large amounts of white bread, then a lack of strength in that country's wheat will mean a large import of strong wheat or flour.

(45) Op.Cit.p.20
(46) Ibid p.23

On the other hand, if the inhabitants do not regard white wheaten bread as a staple in their diet, if they are accustomed, for example, to eat bread made of wheat mixed with rye, the bakers will not find the same necessity for supplementing the indigenous weak flours with stronger imported ones. However, although it may be difficult to say how much strong wheat is needed, we can definitely determine a minimum of wheat imported into these countries, which need not be strong, but merely good enough to form a satisfactory flour unmixed. Thus, of the 225 million bushels imported into the British Isles, 210 million bushels, at a very conservative estimate are imported irrespective of the quality of British wheat. In France (47) where 15 per cent may be regarded as the usual maximum amount of foreigh wheat added to strengthen domestic wheat, the imports of foreign wheat would be just about sufficient to supply this percentage. Most of the imports are probably made for this purpose, in view of the French government's disinclination to import more wheat than is absolutely essential. If the Government regulation requiring millers to use 90 per cent of domestic wheat remains in force, France will require an average of some 30 million bushels of strong wheat in the future.

In the same way, if we arbitrarily assume an admixture of 15 per cent of strong wheat to be added to weak domestic wheats, we obtain a table like the one given below. This table describes the probable maximum amount of strong wheat needed by wheat-importing countries. The total is probably too high for various reasons. In the first place, 15 per cent is rather high. Then there are various countries included in the table, such as Japan and Egypt, that probably import no

(47) Opinion Expressed by French Milling Engineer.

strong wheat whatsoever. However, the object of the table is not to determine exactly how much strong wheat is need by importing countries, but to arrive at a figure that may be regarded safely as the maximum requirement for strong wheat.

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Average Production; Imports; and Probable Requirements of Strong Wheat of Various Countries during the Crop years 1924-25 to 1928-29 (1). In millions of bushels.

Country	Average Production	Average Net Imports	Strong Wheat Probably Required	Balance: Filler Wheat
British Isles	53.6	225.0	8.0	217.0
Italy	211.2	83.7	31.6	52.1
Germany	113.0	79.2	17.0	62.2
France	280.1	46.5	42.0	4.5
Belgium	14.8	40.3	2.3	38.0
Netherlands	5.9	28.7	.9	27.8
Czecho-Slovakia	40.9	20.4	6.2	14.2
Greece	11.5	20.1	2.3	17.8
Switzerland	3.8	16.2	.6	15.6
Scandinavia	23.2	24.2	3.5	20.7
Austria	10.7	15.5	1.6	13.9
Egypt	37.8	10.3	5.7	4.6
Poland	54.8	6.3	7.7	1.4
Japan	38.4	16.7	5.8	10.9
Union of South Africa	7.8	6.1	1.1	5.0
Total	907.5	639.2	136.3	502.9

The table given above does not include all countries importing wheat, but omits very few if any countries importing strong wheat. It is evident that even with the liberal estimate made in the table, the average demand for strong wheat, some 136 million bushels, is not very large.

(1) The first two columns are taken from Wheat Studies Vll 2. pp. 267 and 273.

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On the other hand, Canada produced over 60 million bushels of Nos. 1 and 2 Northern Wheat in 1928-29 (2), a year when the quality of Canadian wheat was well below the average. If therefore, we add United States hard spring and hard winter to the Canadian supply, we see that a glut of strong wheats on the world market is more likely to occur than a scarcity.
We may therefore conclude that Canada has neither a monopoly nor a quasi-monopoly upon strong wheat. In other words, there is not a sufficient discrepancy between supply and demand, actual or potential, to enable Canada to influence the price for strong wheat by artificially controlling its export. On the other hand, this does not mean that Canadian wheat has no natural advantage in competing in the international market. Canadian wheat is undoubtedly the best wheat in the world, and should, other things being equal, command a premium over the price of other wheats; but, as recent events seem to have shown, to insist on this premium when "other things" are not equal may prove to be a dangerous policy.

Conclusions with respect to the wheat to the wheat-importing countries must be similarly indefinite for there is no absolute minimum of wheat that these countries must import. However, in the ordinary course of events, a large part of the 136 million bushels of wheat will continue to be imported, and we may expect the amounts of strong flour imported to increase as the standard of living rises in these countries, and finer, whiter bread is demanded by the working classes.

(2) Report on the Grain Trade of Canada 1929, p.52

Changing Trends in Wheat Production and Consumption.

Just at present, there seems to be a decided lack of equilibrium in the world's wheat trade. Wheat prices are greatly depressed, and literally mountains of wheat have accumulated in exporting countries, waiting to be sold. In this chapter I shall not assume the functions of a Mohammed, but shall merely trace the changes which brought into being the present channels of the wheat trade, and attempt to appraise the position and importance of the various factors influencing the international trade in wheat.

The present channels of trade along which the international movement of wheat takes place are very new. The abnormal state of affairs during the world war brought them into being, and they are very different from the channels that existed previously. Thus previous to the war, the four countries, Canada, United States, Argentina and Australia, supplied approximately 50 per cent of Europe's wheat imports. At present they supply over 90 per cent of the European imports (1). This great change in the source of Europe's wheat imports is the most significant feature of the post war development in the international trade in wheat.

How this came about can be briefly explained. Before the war, Russia exported over 160 million bushels of wheat annually

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(1) United States Dep't. of Commerce: International Trade in Wheat and Wheat Flour p.112

(average 1909-14) (1). The countries of the lower Danube Basin (Hungary, Roumania, and Bulgaria) exported about 110 million bushels during that period. These two areas supplied Europe with large quantities of grain and meat. The deficiency in supply was made up by imports from ex-European countries. But the situation is vastly changed now, exports from the Danube Basin have dwindled to some 35 (2) Million bushels while exports from Russia had almost ceased entirely up to the end of 1929-30. The following table shows the changes that have taken place among the wheat exporting countries.

Change in Export Situation (3)

Country	Exports (in millions of bushels). 1909-14	1924-29	
Canada	95.6	309.5	
United States	110.0	178.5	
North America	205.6	488.0	
Australia	55.2	96.6	
Argentina	84.7	154.5	
	345.5	739.1	
Increase			393.6
India	49.8	8.3	
Danube Basin(4)	109.0(pre-war area)	36.7	
Russia	164.5	16.0	
Total of last 3 countries	323.3	61.0	
Decrease			262.3
Total (including countries not shown)	671.5	784.0	
Net Increase			112.5

(1) Wheat Studies V11.2. p.173
(2) Ibid p.173
(3) Ibid p.173
(4) The exports of the pre and post war countries in the lower Danube Basin are not strictly comparable but a rough comparison between the two may be made.

It is thus evident how new the situation really is. Previous to the war Canada's average exports of wheat (and flour) were less than the amount consumed domestically. Now she is the foremost wheat exporting country in the world. Her domestic production and exports for the period 1924 to 1929 averaged 422 and 310 million bushels respectively(1). This enormous increase in production has been accomplished by a phenomenal expansion of the acreage sown to wheat. Thus Canada's acreage increased by over 100 per cent, from about 10 million acres in 1913 to over 23 million acres in 1921. The rapid increase in wheat acreage in North America and to a smaller extent in Argentina and Australia was due to the stimulus given by the demand from the European Allies who found their supplies from eastern Europe suddenly cut off at a time when their own production was shrinking due to lack of man power. At present Canada's wheat acreage is slightly below 25 million acres(2). It is an axiom about farming that while the acreage sown to a certain crop can be increased easily under the stimulus of high prices the reverse is far from true, and so we cannot expect the wheat acreage in Canada to be diminished very rapidly even though low prices prevail, and Canada will probably remain one of the world's greatest wheat exporting countries for some time to come.

The position of the United States is somewhat different

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(1) Wheat Studies V11.2. pp.167 and 173
(2) Ibid p.165

from that of Canada. Her exports increased, during the period considered, from 110 to about 180 million bushels. At the same time her domestic production increased from 690 to 833 million bushels (1). The increase in wheat acreage in the United States was made under the stimulus of inflated prices and thus the farms and farm implements were capitalized at abnormally high prices. Many wheat growers in the United States were in difficulties even before the spectacular fall in wheat prices in 1930 took place. As a consequence the United States government is attempting to eliminate exports of wheat from that country and then raise the internal price to a figure that will be more satisfactory to the farmer. Other schemes of artificially stimulating the price of wheat in the United States have broken down because of the export surplus that had to be sold in the world market. It is significant that in spite of all the efforts of the United States Government there has been no material reduction in the wheat acreage.

The increase in Argentine exports, as shown in the table above of some 80 per cent has been accompanied by an increase of some 93 million bushels in domestic production, from 147 to 240 million bushels. It will be seen that about 75 per cent of the increased production was exported while the remainder was consumed

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(1) Wheat Studies V11.2. pp. 167 and 173

within the country. Argentine land that is brought under the cultivation is usually taken from pasture areas, and since the land once brought under cultivation cannot be reconverted into pasture land within a short time, the Argentine wheat acreage cannot be reduced very easily.

Australian wheat crops increased from a pre war average of 90 million bushels to 144 million bushels (1), an increase of 54 million bushels of which some 40 million bushels were exported. According to Baker (2), nearly half of Australia's cultivated land was in wheat (1925) and he predicted a decline in acreage to 30 per cent of the total. However, as he estimates that Australia could produce a maximum of over 400 million bushels of wheat, this decline would probably be relative and not absolute. We may, however, expect that even if favorable conditions were to exist, Australia's wheat acreage would not expand very rapidly in the near future.

The decline of India's exports by some 40 million bushels, was accompanied by a slight increase in wheat acreage and a decrease in the average size of the crop harvested from 352 million bushels to 328 million bushels (3). The decline in exports is much greater than the averages indicate. For at present India's exports of wheat are very irregular and in two years since 1920 imports of wheat into India exceeded exports by a large amount. This is not

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(1) Wheat Studies V11.2. p.167
(2) Economic Geography Vol.1.1925. O.E.Baker: The Potential Supply of Wheat
(3) Wheat Studies V11.2. pp.165 and 167.

surprising, since India, with a population more than twice that of the United States (1) produced less than half the amount of wheat grown in the United States (2). It is therefore probable that India will cease to be a wheat exporting country in the near future and become a wheat importing country.

The countries of the lower Danube Basin have seen their exports of wheat dwindle to almost one third of the pre war level (the post war States are not strictly comparable with the pre war States, but if the area is taken all together a rough comparison may be made). In the first place,there has been a distinct shrinkage in the wheat crops raised from a pre war average of 330 million bushels to a post war average of 287 million bushels(3). Before the war exports from the Danube Basin came mostly from Roumania and Hungary. Roumania then exported over 70 per cent of the wheat available for consumption (4). This very high percentage of exports was due to the fact that more than half of the wheat ~~were~~ grown was produced on large estates mainly for export, and because the peasants subsisted largely on corn and used wheaten bread to a very limited extent (5). These conditions also prevailed in Hungary,but to a more limited extent. After the war,conditions changed com-

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(1) International Year Book of Agricultural Statistics.1929-30. p. 5 et. seq.
(2) Ibid. p.143 et.seq.
(3) Wheat Studies V11.2. p.168
(4) Wheat Studies V1. 5.p.261.
(5) Ibid. p.261.

pletely. The percentage that exports formed of the available surplus of the whole region fell from 40 to 16 per cent. Thus in spite of the fact that Roumanian territory was more than doubled after the war, her exports of wheat fell from 53.4 to 8.2 million bushels. Similar decreases occurred in the other Danubian countries but to a smaller extent. This decrease was due to the break-up of large estates and the redistribution of the land among the peasants in Roumania. Small holdings in the other Danubian countries were also increased. As a result of the peasants' more inefficient methods of cultivation the yield per acre diminished considerably and the total production declined. At the same time domestic consumption of wheat has increased. These factors caused the great diminution in exports. With regard to the future it does not seem probable that the Danube Basin will regain its pre war position as a wheat exporting country. Practically all the land available for cultivation is being used now and any increase in yield per acre will probably be offset by an increase in the industrial population which is wheat consuming.

(1) The Wheat Studies state, with regard to this problem:

> "In Short, the outlook for exports is obscure because one cannot anticipate whether recovery of yield is likely to advance more rapidly than population growth and shift to industrialization, with concomitant increase of domestic consumption of wheat."

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(1) Op.cit. Vl.5. p.270

The greatest change in the pre war situation is the disappearance of Russia from the export market. At the same time this change is the most easily explained. The advent of the Soviet Government in Russia marked the disappearance of the great landed estates. However, as the confiscated estates were divided up among the landless classes, the average size of land holdings in Russia was increased by very little between 1917 and 1919 (1). The Soviet Government was from the first unsympathetic to the peasant, and such episodes as the forcible seizure of the peasants' surplus crops in 1918 and 1919, and more recent attempts at forcible collectivization of all land holdings have made a great proportion of the peasants suspicious of the Soviet regime. On the other hand voluntary collectivization has made great strides recently, and the state has begun to develop large farms under its own control. At the same time the government is making strenuous efforts to introduce the most modern agricultural machinery throughout Russia. As a result, production of wheat in Russia, which had fallen to almost half the estimated pre war average of about 760 million bushels by 1923, began to increase rapidly. By 1927 the pre war level was surpassed, and the 1930 crop reached the amazing level of 1,157 million bushels (2) of wheat, an increase of 410 million bushels over the 1924-28 average, and of 455 million bushels over the pre-

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(1) H.S.Patton. The World's Wheat Trade. p.27
(2) Wheat Studies VII.2. p.167.

vious year. The Soviet Government have also announced their intention of increasing their wheat acerage so that the 1931 crop will exceed that of 1930 by 400 million bushels. If this is done, it will mean an increase of production in two years of 855 million bushels of wheat, an amount greater than the total international trade in wheat. Russia has already signalled her return to the international wheat market during the present crop year by "dumping" large amounts of wheat in European countries, to the detriment of the other wheat exporting countries. The whole situation hinges on whether Russia will be able to export large amounts of wheat. Previous to the war, the area included within present Soviet Russia had a population of 144 million people (1) and had a surplus (exclusive of exports) of some 605 (2) million bushels. This would mean a per capita disappearance of 4.2 million bushels (making no allowance for seeding etc.). The present population is 158.5 million. If, therefore, we make the same allowance for(3) per capita disappearance, namely 4.2 bushels, we obtain 665.7 million bushels as the domestic requirement. It is therefore evident that in spite of the probable increased domestic consumption that will follow the industrialization of Russia, she will have a large surplus of wheat to export, and if wheat production actually is raised to 1,500 million bushels per annum, the surplus will be enormous. There can be no question about Russia having the available

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(1) International Year Book of Agricultural Statistics.1929-30.p.2.
(2) Ibid. pp. 143 and 265.
(3) Ibid. p.2.

land to sow to this increased acerage. Baker (1) calculates that if 30 per cent of the land physically available for wheat in Asiatic Russia were devoted to this crop, and the yield raised to 15 bushels per acre, this region could produce 1,400 bushels of wheat, an increase of some 1250 million bushels over the pre war output. At the average yield per acre in post war Russia, 11 bushels (1924-28), 30 per cent of this area could produce some 1,000 million bushels, or 850 million bushels above the pre war level. We cannot doubt, therefore, that if conditions continue as they are at present, Russia can, if she wishes, become the largest wheat exporting country of the world (provided that wheat importing countries do not place embargoes on Russian wheat). We must also remember in this connection that exports of Russian wheat are not influenced by the price in the way exports from other countries would be. The position of the Russian exporters of wheat is somewhat similar to that of the United States Federal Farm Board. In each case they have wheat to sell at the best price they can get for it, but this price need not necessarily cover the cost of production.

The changes in the European import situation from pre war days were not considerable. The importing countries of Europe (i.e. Europe exclusive of the lower Danube Basin and Russia) suffered a decline in the domestic production of wheat of 8 per cent,

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(1) O. E. Baker, Economic Geography Vol. 1. 1925. p.46

at the same time their imports increased by 13.4 per cent. The net result was a diminution in total wheat consumption of 0.4 per cent. This diminution in consumption took place in spite of an increase of 5.9 per cent in the population of the area under consideration, from 1913 to 1929. The following table shows the changes graphically.

Approximate Changes in the Consumption of Wheat in Europe (1) (ex Russia and Danube Basin).

	1909-1913 inc. 000,000 omitted	1926-1929 inc. 000,000 omitted	Change 000,000 omitted	Percentage Change %
Population	353	374	121	+ 5.9
Production	1,158.7 bu.	1,074.3 bu.	-84.4 bu.	-7.3
Net Imports	548.9 "	626.6 "	77.7 "	+13.4
Consumption	1,707.6 "	1,700.9 "	-6.7 "	-0.4
Consumption per capita(bushels)	4.84	4.57	-.27	-5.6

There is therefore a slight, but distinct, decrease in the consumption (disappearance) of wheat in Europe. This trend is more noticeable in some countries than in others. The table below shows the changes that have taken place in the more important wheat importing countries.

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(1) This table was prepared from data on population, production and movement of wheat, given in tables 1, 52, 102, and 103 of the International Yearbook of Agricultural Statistics. 1929.30.

Changes in the Consumption of Wheat in Important Wheat-Importing Countries.

Country	1909-13 ooo,ooo omitted				1924-29 ooo,ooo omitted				Change in Consumption %
	Population	Production	Net Imports	Total Consumption	Population	Production	Net Imports	Total Consumption	
British Isles	45.9	59.6	217.7	277.3	48.8	53.6	225.0	278.6	+0.47
France	39.8	325.6	43.6x	- -	41.3	280.1	46.5	326.6	- -
Germany	67.0	131.3	67.8x	- -	64.7	113.0	79.2	192.2	- -
Italy	35.6	182.9"	53.0	235.9	41.5	211.2	83.7	294.9	- -
Belgium	7.6	14.9"	50.2x	65.1	8.1	14.8	40.3	55.1	-15.4
Netherlands	6.2	5.0	22.6	27.6	7.8	5.9	28.7	34.6	+25.4
Switzerland	3.9	3.3	16.9	20.2	4.0	3.8	16.9	20.7	+ 2.5
Austria	29.2	12.8	10.5x	- -	6.7	10.7	15.5	26.2	- -
Greece	4.8	16.3	6.9x	- -	6.2	11.5	20.1	31.6	- -
Scandinavia	10.9	13.9	17.4x	31.3	12.5	23.2	24.1	47.3	+51.1
Japan	55.1	32.0	4.1	36.1	62.9	38.4	16.7	55.1	+52.8
Egypt	12.1	33.7	8.3	42.0	14.2	37.8	10.3	48.1	+14.5
Union of South Africa	6.2	6.3	6.3	12.6	7.9	7.8	6.1	13.9	+10.3
Brazil	24.6	1.5	20.7	22.2	40.3	4.7	33.9	38.6	+73.9
Czechoslovakia	- -	37.9	- -	- -	14.6	40.9	20.4	61.3	- -
Poland	- -	61.7	- -	- -	30.7	54.8	6.3	61.1	- -

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(1) " - Includes pre war areas.

x - Not comparable with post war imports.

Changes in the Consumption of Wheat in Important Wheat-Importing Countries (Continued).

Country	1909-13 Per Capita Consumption Bushels	1924-29 Per Capita Consumption Bushels	Change in Per Capita Consumption %
British Isles	6.0	5.7	- .3
France	- -	7.9	- -
Germany	- -	2.9	- -
Italy	6.6	7.1	+ 7.6
Belgium	8.6	6.8	-20.9
Netherlands	4.5	4.4	- 2.2
Switzerland	5.1	5.2	+ .2
Austria	- -	3.9	- -
Greece	- -	5.1	- -
Scandinavia	2.9	3.8	+23.7
Japan	.65	.9	+38.5
Egypt	3.6	3.4	-5.5
Union of South Africa	2.0	1.8	-10.0
Brazil	.9	.96	+ 6.6
Czechoslovakia	- -	4.2	- -
Poland	- -	1.9	- -

The population figures, and the pre war production figures of Italy and Belgium are taken from the International Yearbook of Agricultural Statistics. The remaining figures of Imports and Production are taken from Wheat Studies V11.2. pp.167 and 173. Production figures are for post war areas.

The gaps in the above table are due to the difficulty of obtaining comparable statistics of pre war and post war areas. While such statistics may be obtained with regard to production of wheat, it is virtually impossible to revise the figures of imports and exports of the countries whose boundaries were greatly changed by the war, so as to make them comparable. The results obtained are fragmentary. According to the table there have been substantial increases in consumption in Italy, Scandinavia, Japan, and Brazil. The increased consumption in Italy has been effected by increases both in domestic production and in imports, although the proportionate increase in the latter was much greater. There has been an undoubted increase in consumption of wheat in the Scandinavian countries, production and imports have increased, especially the former. The increase in Japanese consumption has been effected largely through increased imports which quadrupled in this period. Brazilian increased consumption was made largely through increased imports since very small amounts of wheat are grown in that country. It is to be noted that with the exception of Italy, all the increases in wheat consumption took place in minor wheat importing countries.

Decreases in consumption were rather small except in the case of Belgium and the Union of South Africa. The decreased consumption in the former is rather remarkable although it undoubtedly seems to have taken place. Changes in consumption of the other countries cannot be determined from the statistics at hand.

With regard to the whole question of consumption trend, Wheat Studies (1), after making an elaborate survey of the situation concludes:

> "It is clear that no substantial change in the level of per capita consumption is under way in the United States, the United Kingdom, or India, which with Russia, France and Italy, are the world's largest consumers of wheat. In France, Spain and Canada, three other large consumers, no tendency to change in level of per capita consumption is in evidence, though for France and Spain the wide range of variation in the utiliz ation figures might readily conceal important changes in the level....It is worthy of note, however, that in the United States, the United Kingdom, and probably in Canada also, the post war level of per capita consumption is appreciably below the immediate pre war level: in the United States and probably in Canada about 10 per cent, and in the United Kingdom about 5 per cent below the pre war level."

Wheat Studies (2) continue:

> "In no country do we find any striking tendency toward decrease in wheat production, even relative to population growth....In about every other country of Europe (other than the British Isles and France where the tendency is downward) the tendency is toward slightly expanding production."

We may now devote some attantion to ex-European countries that import wheat. According to Wheat Studies (3), four fifths of the approximate 800 million bushels of wheat exported annually (average 1922-23 to 1928-29) went to Europe. Of the remainder,

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(1) Wheat Studies Vl. 10. p.433.
(2) Ibid p.432
(3) Ibid p.425.

some 50 million bushels went to the Orient, 70 to 80 million bushels went to Mexico, the tropics and Africa exclusive of Egypt, and 10 million bushels to Egypt. These exports were divided up as follows. The wheat imported by the Orient came mainly from North America and to some extent from Australia, the tropics and Mexico were supplied by North and South America in equal proportions. Europe's supplies originated two-thirds in North America, one quarter in Argentina, one twelfth each from Australia, and India and Russia and the Danube Basin together.

The group considered under the head of tropical countries include most of the countries withim the tropics excepting India, Mexico, and a few other countries in South America and in Africa for which statistics were not available and Brazil which has already been considered. The countries considered here grew very little wheat domestically and consumption figures practically coincided with imports of wheat. The total population of the countries consideredwas about 180 million in 1926, while their total consumption of wheat (1923-27 average) was 36.9 million bushels per annum (1). Thus their per capita consumption was only about 0.2 bushels at this time. However, in such a large population, a slight change in per capita consumption would mean a considerable change in the total amount consumed. The following

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(1) Wheat Studies. Vl. 7. p.341.

table adapted from a survey of the wheat consumption in the tropics made by Wheat Studies (1) shows the consumption trends in these regions. The countries are arranged in five territory groups.

Population, Total and Per Capita Wheat Consumption in Tropical Countries.

Averages of 1909-13 and 1923-27.

	Population July 1.,000 omitted		Total Consumption. Thousand bushels		Per Capita Consumption pounds of flour		Percentage Change in Per Capita Consumption
	1911	1925					
Asia	74,950	93,504	6,122	11,299	3.43	5.08	+48.0
Africa	54,210	60,885	1,692	2,554	1.31	1.76	+35.6
Central and South America	14,370	16,450	5,975	8,117	17.46	20.72	+18.7
West Indies	8,300	9,835	10,544	13,532	53.36	57.79	+ 7.6
Oceania	713	862	1,259	1,347	74.16	65.63	-11.5
Total	152,543	181,536	25,592	36,849	7.13 or .164 bushels	8.83 or .203 Bushels	+23.8

It is evident that there has been a marked upward tendency in wheat consumption in these regions, especially in the first three territorial areas. As far as can be judged, these tendencies will probably continue in the future. Wheat Studies state (2):

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(1) Op.cit. Vl.7. p.348
(2) Ibid p.349

> "It seems reasonable to suppose that the upward tendency of total and per capita consumption in tropical countries in post war years has been due in large part to persistent and deep-rooted causes. Possibly these causes include a widespread improvement in the standard of living involving an increase in the total per capita intake of food...(or they may) include displacement of other cereals in the diet for reasons of price or of preference. To designate the causes involves a good deal of mere speculation... Yet one may reasonably conclude that the forces making for increased consumption in tropical countries are strong ones."

It remains, however, to place the consumption of wheat in the tropics in its proper perpective. We have noted an increase of about 35 per cent in total consumption in the tropics in about 15 years, an absolute increase of some 9 million bushels. If consumption were to increase at a slightly higher rate for the next 15 years, the increased amount of wheat consumed would be about 15 million bushels. The recent reduction, within a short time, of the quota of indigenous French wheat to be used in mill mixes from 90 per cent to 80 per cent, can conceivably have a greater influence in the international trade in wheat in one year, than consumption in the tropics would probably have in 15 years.

We may now turn our attention to eastern Asia and trends in that region. The area here considered is Japan and China. The most peculiar feature about the consumption of wheat in the Orient, is the fact that a large proportion of the wheat used as food is not ground into flour. Thus in 1922-23 (1), 67 per cent of the

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(1) Wheat Studies Vl.8. p.362

wheat was converted into flour, 21.5 per cent was used in making sauces, 3.7 per cent was used as feed and seed grain, and practically all the remainder was used as foods of various kinds. It must be noted too that fuel for fire is scarce and rather expensive in Japan and many parts of China. As a consequence, baking, which is rather wasteful of fuel, is not carried on in the homes of the people but in bakeries in the large cities only. Yeast is also difficult to obtain in Japan, due to the warm climate. These two factors undoubtedly play a part in keeping down the consumption of baked bread in the Orient.

In Japan and in southern China wheat is regarded as a luxury while rice forms the staple food in the diet. In northern China and Manchuria wheat is the principal food while rice is the luxury. Wheat Studies (1) state that the southern Chinese have a prejudice against wheat because they dislike its flavour. However there has been a steady stream of migrants from the wheat-consuming north to the south in recent years, and the large number of soldiers now existing in China are also wheat-consuming because the soldiers are more easily fed by bread than by rice. These two large bodies are increasing the amount of wheat consumed in southern China by actual consumption and by example. The actual rate of increase in consumption in China cannot be estimated due to the lack of

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(1) Op. cit. Vl.8. p.351.

relevant statistics. In Japan, while there has been a considerable increase in the consumption of wheat, bread or wheat products cannot be regarded as occupying a very important place in the Japanese diet. According to Wheat Studies (1) the per capita consumption of wheat in Japan has more than doubled within the last fifty years, while the increase in rice consumption has been much smaller, but the consumption of wheat still remains about one tenth of that of rice. This preference for rice be it noted, is maintained in spite of the seemingly greater cost per calorie of rice.than flour.

From the viewpoint of international trade the changes were not of exceeding importance. There has been an increase in net imports of wheat and flour into Japan of some 12 million bushels from 1909-14 to 1924-29. The preference for rice among the Japanese seems to be firmly fixed, and there is no reason to expect an unusual increase in the per capita consumption of wheat in Japan in the near future (2). If the increase in consumption continues in the future as it has in the past, it will probably mean an increased importation of some 20 or 25 million bushels of wheat in the next 15 years, for there is very little land in Japan available for wheat or that is likely to be sown to wheat in the near future (3), and increased consumption will probably be reflected in increased imports.

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(1) Op. cit. Vl.8. p.369.
(2) Ibid p.369.
(3) Ibid p.353 et.seq.

We cannot be so specific in discussing possible future trends in China. That country is in a state of greater or less disorganization. Large bodies of soldiers have, presumably, been withdrawn from productive work, and the production of those remaining on the soil must have been seriously interfered with. It is therefore natural to assume that China would be now importing more food of all kinds than she would be doing normally. At the same time, countries suffering such wars as China, usually witness a decline in the standard of living after these wars have been concluded. This decline would probably mean a corresponding decline in international trade, and would hardly be conducive to increased imports of food. Such increased imports could easily take place as relief measures or through the charity of foreign bodies, but they would not become established as a permanent feature of international trade.

The statistics of China, such as are obtainable are as follows. Wheat acreage in China was (1918) about 50 million acres (1). The amount of wheat harvested is not known but the yield per acre is stated to have been less than that in the United States, because Chinese wheat is planted mainly in alternate rows with other crops. If the yield was over 8 bushels per acre, China's wheat crop for that year was greater than that of Canada. The average imports of wheat and flour into China annually from 1909 to 1913 were about 200,000 bushels. China exported some 3.6 million bushels of wheat, probably to Japan to be milled, and imported an amount of flour equivalent to 3.8 million bushels of wheat. In the

(1) Econ.Geog. 1925. 1. p.29.

three years 1926 to 1928, she imported 3.3 million bushels of wheat, and flour corresponding to 14.3 million bushels of wheat annually. The exact significance of this increase of imports cannot be determined for the reasons outlined above. We may therefore conclude that while the per capita consumption of wheat in China is probably increasing, it is impossible to foretell how this will affect China's international trade in wheat and flour.

We have now briefly surveyed post war trends in the production and consumption of wheat. We have seen that the greatest changes in the supply side have been the decline of Russia, India, and the Danube Basin. While the decline of the latter two is very probably permanent to a great extent, Russia has seemingly suffered only a temporary eclipse and should soon be exporting wheat on a greater scale than ever. To balance this decline, exports from Canada, United States, Argentina, and Australia have increased greatly. Of these countries, we may look to a decline only in the United States, and possibly Australia to a small extent. Canada and Argentina willprobably continue their production and their competition.

On the import side we see that Europe still remains the great wheat importing area. Wheat production in Europe is probably increasing, but at the most is increasing at the same rate as population growth. In spite of all stimulation of Governments, production in Europe is steadily falling behind the demand of the European population. Per capita consumption, on the other hand has

probably not increased, in all the major wheat importing countries with the exception of Italy. We cannot say whether this is merely a temporary regression caused by the war or is a permanent influence. However there seems to be a maximum amount of per capita consumption of wheat(1), after this level is reached wheat is replaced by other more expensive foodstuffs. Most of the middle and west European countries seem to be close to this level, with the notable exception of Germany.

Consumption in ex-European wheat importing countries seems to be increasing rapidly. However, their total volume of wheat imports is so small that the absolute increase in wheat imports is not considerable.

In short, we may expect a small but steady increase in the wheat imports of Europe, and a more rapid but relatively unimportant increase in ex-European imports. The exporting countries could approximately balance this rate of imports if Russia were to stay out of the market. However Russia will probably not stay out, and unless some international agreement to restrict exports is reached, we seem to be at the beginning of an era of low wheat prices and cut-throat competition.

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(1) cf. Wheat studies II.8. "The Decline in Per Capita Consumption of Flour in the United States," of which the following extract (p.288) is illustrative: "The most striking and significant characteristic of the changes in food consumption(in the United States) since 1919 is the tendency to increased consumption of the more expensive foods and to decreased consumption of the less expensive foods." The forces tending to bring this about are (p.292): "Increasing prosperity,diversification of the diet and declining food consumption."

Chapter 6.

Summary and Conclusions.

We have now made a brief survey of the place in the economic sun of wheat in general and Canadian wheat in particular. We have seen that bread occupies an important place in the white man's diet. This position of bread is justifiable from the viewpoint both of economics and of physiology. Bread is the cheapest food a man can have; and, at the same time, is extremely useful in the formation of a balanced diet, since it supplies a plenitude of carbohydrates, and a smaller but important nucleus of proteins, mineral matter, and vitamins. France, with the greatest per capita consumption of bread, has a very low priced diet. While such nations as Great Britain, United States, and Canada will probably decrease their per capita consumption of bread, the consumption of other nations will probably increase.

The pre-eminent position of wheat as the staple cereal of consumption is threatened, notably, by two other cereals: rye in such European countries as Germany, Russia, and the States adjacent to the Baltic; and rice in the Orient. Rye is a very hardy cereal. It grows in places unsuitable by soil or climate for wheat culture. This in itself is a force tending towards its conservation. Rye is also a poor man's food. Rye bread is cheaper than wheaten bread and is therefore consumed by the poorer classes in preference to it. Apart from this, habit and tradition have established rye bread as the staple bread for many people regardless of enonomic considerations. This is clearly seen in North America where rye bread is eaten by

groups of immigrants and their descendants. Working in opposition to these forces however, there is the strong feeling of revulsion against rye bread in Europe brought about by war conditions. This feeling is so strong that observers are unanimous in reporting a shift in consumption from rye to wheaten bread. If this change were to be rapid, imports into these countries might increase appreciably within a few years. However, there is no sign of this taking place in the near future, and the financial position of one of the most important of these countries, Germany, is such, that an increase in imports of any kind is very difficult. Rice, the staple cereal in the Orient, occupies a more prominent position there than does wheat in the West. It is the chief, and in many places almost the sole article on the diet. Its main defect, from an Occidental viewpoint, is that it cannot be baked into a bread. Physiologically little would be gained by substituting wheat for rice. However this substitution is taking place, although wheat is still an unimportant foodstuff in rice eating countries. There is also reason to believe that the potato will be substituted for rice more rapidly than wheat. All in all, wheat is making headway against its rivals rye and rice, but its progress against the former is so slow, and its total consumption in the region of the latter is so small, that the influence of this movement on the international wheat situation is very slight.

We found that it was a difficult matter to compare the quality of the wheats grown in various parts of the world. This was due to the enormous number of varieties grown, the numerous

properties of wheat and flour in which each variety could excel or be deficient, and the difficulty of comparing the results obtained from different tests. We found that wheat could be divided into two main groups: the bread wheat species and other species. The latter group contained only one important species, durum wheat. While samples of all species of wheats were grown in many countries, there were only a few in each country of sufficient importance to warrant their being considered. We saw that the most important characteristic of wheat was its baking strength, and that the only way of determining this absolutely was by actually baking bread made from these wheats, under specified conditions. Results of numerous tests showed that the various classes of wheat ranked as follows in quality: hard red spring, hard red winter, white, soft red winter. Hard red spring export wheat came from Canada, United States and Russia, in the order of their quality. Hard red winter, in order of quality came from United States, Argentina, Russia and the Danube Basin. White wheat, which is generally somewhat better than soft red winter is exported from United States, Australia, and India, ranked according to quality. Soft red winter wheat in the order of quality, is exported from United States, Russia, and the Danube Basin. Durum wheat is often regarded as being too weak for bread making purposes. It is excellent for making pastry, etc. It is produced in important quantities in Russia, Canada and the United States, and the Danube Basin, in that order of quality. Thus the statement that number one Manitoba hard spring wheat is the best commercial class of wheat in the world is undeniably true.

Exports of wheat go largely to Europe. In spite of the fact that Europe is a great producer of wheat, four fifths of the world's exports go to that continent. Exclusive of Russia and the Danube Basin all European countries are importers of wheat. Wheat grown in Europe belong to all the commercial classes mentioned above. However, the amount of spring wheat grown is small and this wheat is conspicuously weaker in baking strength than the spring wheat of exporting countries. There is some hard red winter wheat grown in Bulgaria but the amount is so small that it is negligible. Soft red winter wheat is the most common wheat grown in Europe. Although soft red winter is not a strong wheat, the European varieties are much weaker than, for example, American soft red winter. White wheat is rather unimportant commercially in Europe. It shares the common European characteristic of weakness. Durum wheat, grown only in large amounts in Italy, was very weak. This weakness of the European wheats is their most outstanding characteristic. However, an analysis of European domestic production and import requirements shows that normally the demand for strong wheats for blending can be plentifully supplied by North America. Ex-European importing countries also have characteristically weak wheats, but do not import strong wheats to improve their mill mixes.

The most surprising aspect of the international wheat situation is the rise to prominence of Canada in so comparatively short a time. It was only in 1912 that Canada exported, for the first time, more wheat than she used domestically, while at present she is the foremost wheat exporting country in the world. Similar

smaller increases occurred in the other wheat exporting countries with the exception of Russia, India and the Danube Basin, whose exports diminished considerably. The extent to which these changes are permanent is a major wheat problem. It is probable that among the former group of exporters, the exports of the United States will decline, while those of the rest will remain at about the present level. In the latter group, the decreased exports of India and the Danube Basin are probably permanent while the position of Russia is problematical. In Europe, ex-Russia and the Danube Basin there has been a slight decrease in total consumption and consequently a somewhat greater decrease in per capita consumption since pre war days. However, the present tendency of per capita consumption in Europe seems to be upward. The trend of consumption in the Orient and the tropics is markedly upward. There has been a considerable increase in wheat consumption in these regions since the pre war period, and the present tendency seems to be still distinctly upward. However the total consumption in these regions is so small that the actual increase in consumption is rather unimportant from the point of view of the wheat exporting countries.

Very little has been said, here, about the depressed state of wheat production throughout the world, because it does not concern us directly. However, a short account of the present situation would not be out of place. The underlying cause of the present situation was the occurrence of an event that authorities repeatedly assured us could not occur, that is, a universal bumper crop. This happened in the crop year 1927-28. And to prove to the

authorities that they were quite wrong, an even greater bumper crop was hargested in 1928-29. In 1929-30 the exporting countries had a rather small crop but France, Germany and Italy had large crops of unusually good quality. Meanwhile the economic depression was becoming increasingly severe. The results of these events were shortly, as follows. The bumper crop of 1927 enabled the importing countries to build up their domestic stocks. The following bumper crop of 1928 could not be all marketed, and early in 1929, when the size of the crop was fully realized, wheat shipments began to decline. Finally the diminished imports of three of the great importing countries in 1929-30, at this critical time gave the final impetus to the spectacular decline in wheat prices. Thus the present situation is that there is a very heavy accumulation of wheat stocks in the United States and Canada. This surplus would presumably have been disposed of by increased domestic utilization and exports during short crops. However the re-entry of Russia into the wheat market has upset all calculations, and the future is doubtful. The logical thing to do would be to apportion export quotas among the exporting countries by international agreement until the situation becomes normal once more. However this does not seem likely to happen. The decisive factor in the whole situation is Russia, and the extent to which she will re-enter the export market.

The conclusions therefore are.

1. The place of wheaten bread in the diet is justified.
2. The consumption of wheaten bread will probably increase

in most countries.

3. Although wheat is competing successfully with rye and rice, the consequent increased consumption will not be very great.

4. Canadian hard red spring wheat is superior to all other wheats, but its superiority over United States hard red wheat is not great.

5. Europe cannot be self-sufficing with regard to wheat.

6. The demand for strong wheat is not greater than the supply.

7. Wheat consumption trends in Europe and Asia are upward.

8. Russia is the disturbing factor in the present depressed wheat situation; and therefore, if we wish to know what the future holds in store, we must, Mohammedan-wise, turn our faces toward the east, and look for a sign.

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