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◆ 초청원고 ◆

Wheat Research and Technology in Australia

by

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오스트레일리아에 있어서 小麥의 硏究와 加工技術

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Abstract

Cereal production and utilization in Australia are described briefly. Emphasis is on wheat which is the principal cereal crop for both "home" use and for export.

Some of the main fields of research on wheat quality and process technology are outlined. Reference is made to basic scientific studies in plant physiology, biochemistry and dough rheology, and a more detailed account is given of work at the Bread Research Institute on milling and baking technology.

Cereal Crops

Cereal crops from a large part of Australian agricultural production, and cereal grains are amongst the main export commodities of the country. Wheat is the principal cereal crop. It is cultivated on large tracts of land in the areas shown in Figure 1, to yield a total harvest of approximately 10 million tonnes in a good year. Barley and oats are other major cereal crops while rice and rye are grown in significant quantities but on limited areas.

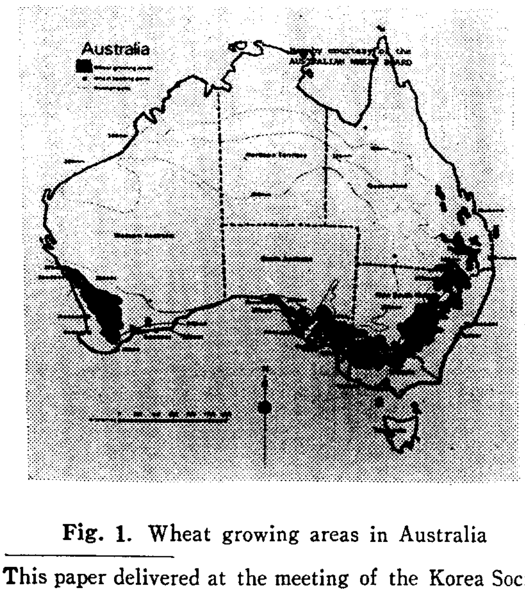

Fig. 1. Wheat growing areas in Australia

Wheat cultivation is particularly suited to those areas where the expected annual rainfall is from 300 to 600mm, and the summer climate is mainly hot and dry. The actual fall of rain is irregular from year to year over much of the wheat growing areas of Australia so that in a drought year a much lower total harvest may be obtained. The mean yield of wheat from areas normally sown (10 year average) is approximately 1.2 tonnes per hectare. The highest yields from the most favourable conditions may be up to 4 or 5 times this quantity.

Crops of wheat are grown on a variety of soil types including loose sandly loams, red-brown clay soils and deep black alluvial soils. Seeding is done in late autumn to early winter (May to July). Germination normally takes place quickly and growth continues through winter and spring to reach maturity and harvest in early-to mid-summer.

Wheat Utilization

Consumption of wheat within Australia is now app-

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roximately 1.8 million tonnes per annum. The remainder of the crop is exported on the world market.

Foods prepared from wheaten materials are consumed extensively by the Australian people. Most of these foods are prepared from flour, with relatively small quantities prepared from semolina, wheatmeals and whole grains. Some of the main wheaten foods are listed in Table 1. Bread is a staple of the Australian

Table 1. Australian foods produced from wheat

Bread-white, Eilk, wholemeal
"Breakfast" foods-whole wheat flakes and puffs
Pies, pasties and sweet pastries
Cakes
Biscuits and Cookies
Pasta-extruded forms
Crumpets

diet, with the mean per caput consumption being now approximately 150g per day or 55kg per year (a decline of some 10% over the past 10 years). Meat pies which have been widely publicised as being typically Australian, are formed from pastry casings with precooked meat fillings and are eaten hot with tomato sauce. Pasties contain a mainly vegetable filling in a folded and crimped pastry case. Crumpets are made by cooking a fluid, leavened batter in rings on a hotplate. This produces a flat, open grained product which is re-heated before being eaten with either sweet or savoury topping.

Industrial uses of wheat now require approximately 0.4 million tonnes per annum, most of which is used in the form of flour. Some 0.25 million tonnes of flour are processed annually to separate starch and gluten. The technology of this process is described in more detail in the final section of this paper. Most of the separated gluten retains its natural vitality and is used in breadmaking to strengthen weak flours having low natural protein content, or to produce special high protein breads. Wheat starch is the principal industrial starch in Australia. It is used extensively in paper making, mineral separation, glucose production and a range of culinary purposes. Pre-gelatinised starch, oxidised starch and several other modified forms of starch have industrial applications in significant quantities. Both wheat starch and whole flour are used in adhesives for bonding plywood.

The wheat offals from flour milling, known in Australia as bran and pollard, are used extensively in prepared animal feeds. Some whole or crushed grain may also be included in high energy feeds.

Wheat Research

The institutions involved directly in research on wheat and wheaten products in Australia include several universities, government departments of agriculture, a unit of the Commonwealth Scientific and Industrial Research Organization(C.S.I.R.O.) and industry supported organizations, the principal one of these being the Bread Research Institute. Research programs are directed toward two broad objectives:

1. Quality improvement and quality evaluation relating to many requirements and uses.

2. Improvements in utilization technology including the retention of nutritional values.

Basic research is outlined under four headings, and some technological work is discussed in more detail below.

Plant genetics and wheat breeding: Several universities and government departments of agriculture are carrying out this work; plant resistance to fungus diseases known as "rust" and "smut" are becoming increasingly important while grain yield and quality of new cultivars must be at least as good as those which they might replace;

Plant physiology and the biochemistry of wheat constituents: The Wheat Research Unit of C.S.I.R.O. is primarily concerned with these aspects and their scientists co-operate closely with several universities. Subjects of particular interest now include the deposition of protein and starch in the developing and maturing grain, morphological structure of grain in relation to hardness and fragmentation in the milling processes, enzyme roles in the development of grain and its subsequent utilization, protein chemistry as it affects dough properties and the qualities of baked foods.

Special research techniques employed in these studies include the electrophoretic separation and focusing of protein fractions, and microscopy using both electron scanning and light instruments with histological sectioning and preparation techniques.

Dough rheology: All foods prepared from milled cereal products have an intermediate stage in the form of dough or batter, the properties of which are critical to the form and quality of the final product; bread doughs are relatively "stiff" and have been shown to be dynamic, visco-elastic systems, which are subject to a form of "work hardening". My colleagues at the Bread Research Institute have developed new types of rheometers employing both parallel plate and concentric tube designs for the study of the fundamental properties of wheat flour doughs under stress.

Dough chemistry: Concurrently with similar interests in several other countries, the nature of chemical bonding in wheat flour doughs and the influence of micro-concentrations of "improvers" on such linkages are being investigated in relation to developments in the technology of dough preparation. The role of lipids in dough development and as an auxilliary to improver action is being studied.

Grain storage and handling problems.

Economic and safe methods of controlling insect pests are of vital concern wherever grain is handled or stored. C.S.I.R.O. scientists are developing physical techniques for rapidly reducing grain moisture and temperature in storage silos as well as studying new insecticides and fumigation treatments. The increasingly specialised markets for wheat for a variety of uses make it essential to have rapid sampling and identification procedures to facilitate segregation of grain types at all main receival and shipping points throughout the country and thus ensure the most economical and advantageous use of the crop. The development and improvement of techniques suitable for hot, dusty conditions particularly techniques for rapid protein determination and grain identification requires the continuing attention of chemists, engineers and statististicians.

Flour milling technology.

Grain conditioning: Australian wheat is normally harvested and delivered to mills at a moisture content less than 10%. Best milling practice requires that the total moisture of the grain be raised to approximately 16% before feeding to the break rolls. The rate and mode of moisture penetration into the several segments of the grain has been studied in the B.R.I. laboratories using autoradiography. A rapid penetration of water into and through the bran layers within one hour has been observed in some wheats and restrictive effect of aleurone cells has been noted in some cases.

Grain structure and hardness: A balance between hardness and protein content is evident in much of the best milling weat throughout the world. The known relationship between grain hardness and morphological structure has recently been examined in more depth, and as a result the significance of endosperm fibre has become more clearly understood. This previously neglected structural component has the biological role in grain of obstructing the movement of the pre-cursors of α-amylase; in milling it can have a negative or hindering effect on the seiving of intermediate mill stocks, but in baking it has a positive effect on flour water absorption.

Nutrition: Modern milling technology achieves a higher yield of flour from grain by the employment of centrifugal forces to break aggregated particles in the head of the milling system; by this means, a greater proportion of endosperm material close to the testa is incorporated in the flour and with it, a greater proportion of the B vitamins and the minerals. Studies in progress are aimed at maximising this trend without incurring adverse effects on other aspects of flour quality.

The current interest in dietary fibre(non-digestible cellulose) is being studied in relation to milling technology while fibre from sevrral sources is being consideredrin terms of breadmaking potential.

Breadmaking.

Australian bread contains less sugar and less fat than Korean bread. These ingredient differences affect both the flavour and texture of the bread. Technological research on all aspects of bread manufacture and distribution is carried out by the Bread Research Institute which is supported financially by the baking and milling industries. Some current projects will be discussed.

Dough preparation and development: For some years, the Institute has been studying and developing procedures for the rapid preparation and maturing of dough. From this work, breadmaking processes which enable bread to be fully baked whithin two hours of commencement of mixing have been developed and are now extensively used for commercial production.

This work has involved the detailed study of theoretical and practical and practical effects of the physical and chemical interactions in dough and bread structures. Early experiments were on the application of intensive mechanical work to dough in batch or intermittent mixing operations. A new design of dough preparation machine known as the BRIMEC was developed and patented. These studies demonstrated the significance of the rate of energy input in mechanical dough development. More recent work on dough development for commercial application has concentrated on the less intensive physical manipulation of dough, coupled with the chemical activation of the re-arrangement of protein bonds to facilitate structural development.

An essential to good bread structure, by whatever means this is formed, is the formation of uniformly thin films of dough capable of retaining the leavening gas, and stretching very considerably under the impetus of sustained gas pressure. The basic functions and stages of dough development during mixing, including that of film formation, are shown in Figure 2.

DOUGH FUNCTIONS	MIXING STAGES
1. **INTERMIXING**	A. **INCORPORATION**
"HOMOGENEITY"	ADHESION
2. **HYDRATION**	PLASTICITY
SWELLING	
GLUTEN	
3. **GLUTEN**	B. **DEVELOPMENT**
"DEVELOPMENT"	COHESION
PHYSICAL	"CLEARING"
CHEMICAL	ELASTICITY
4. **AIR ENTRAINMENT**	FILM FORMATION
CELL NUCLEI	C. **BREAKDOWN**
5. **STABILISATION**	STICKINESS
OXIDATION	PERMIABILITY

Fig. 2. The basic functions and stages of dough development during mixing,

Baking transformation: Dough itself is inedible and its transformation to bread by baking tends to be thought of as a simple, though necessary process. In fact, this transformation involves a complex interaction of heat, water, protein, starch and enzymes. In contrast to dough which is plastic and viscous, bread is characterised by its resilience. A significant relation between the resilience of bread crumb and the completion of baking as determined by organoleptic evaluation has been demonstrated in our recent studies. This relationship is illustrated in Figure 3. The measured values of resilience rise rapidly during the baking period and then become practically constant. The point at which increase of resilience becomes negligible has been found to coincide with the subjective judgment of adequate baking.

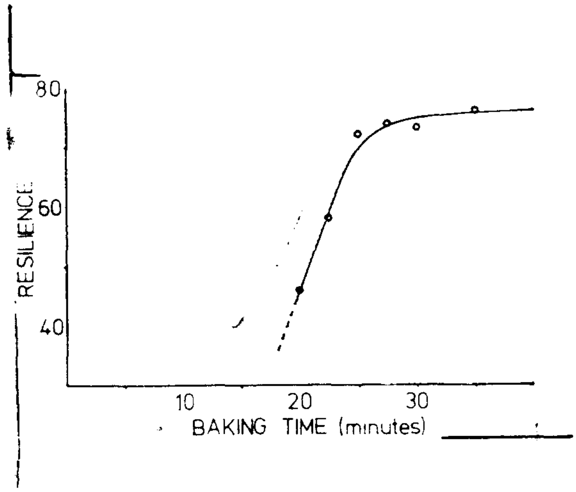

Fig. 3. Relation between resilience of bread crumb and baking time

Wheat Starch, gluten & Glucose.

The industrial process of separating starch and gluten from a wheat flour dough has been pioneered and technologically developed in Australia. It is now a large industry processing approximately 0.3 million tonnes of flour per year.

Both batch and continuous processing equipment are used to prepare dough from flour and water and to knead this in a stream of water to effect the separation of starch from gluten. Best results and yields are obtained from the use of "hard" water and occasionally a weak brine is used. Prime starch is separated from the liquor by settling and centrifuging. Gluten can be concentrated to over 80% protein in the dry matter but a lower concentration of approximately 73% is more suitable for adding to bread dough. Temperature must be carefully controlled to avoid denaturation in the drying of gluten. Some of the starch is for glucose manufactue, with both acid and enzyme hydrolysis being used in the conversion.