Paper 2

USES AND PROCESSING OF GRAIN MAIZE IN NEW ZEALAND

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INTRODUCTION

Maize grain use in New Zealand is split approximately 70% in the feed industry, 19% in the wet milling industry and 10% in the dry milling industry. A small quantity may be used for alcohol manufacture, but for reasons of commercial confidentiality I have been unable to determine the quantity used in that industry.

In this paper I will discuss each industry in turn, but first I will digress to briefly describe the composition of the dent maize kernel because this broadly dictates the processing uses of maize, both because of its chemical composition and physical state.

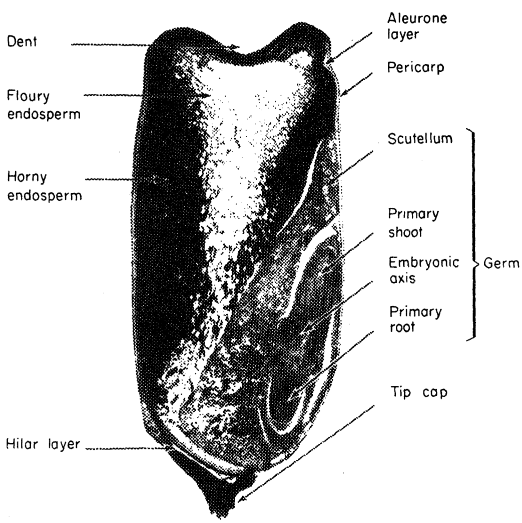

Figure 1. Maize grain anatomy.

THE MAIZE GRAIN

The three components of the grain of interest to the processor are the endosperm, the germ and the pericarp (Fig. 1). The approximate composition of a mature dent maize kernel is given in Table 1.

Table 1: Composition of the kernel of mature dent maize.

	Dry weight (%)	Starch (%DM)	Fat (%DM)	Protein (%DM)
Endosperm	83	86	1	9
Germ	11	7	35	18
Pericarp	6	7	1	4
Whole kernel	100	73	5	10

(DM = dry matter)

The endosperm is the principal source of starch which is in two forms; large starch granules with a thin protein matrix lightly packed together in the floury endosperm; and smaller starch granules which are surrounded by a thicker protein matrix tightly packed in the horny endosperm. The germ, or embryo, is the principal source of fat, which is the basis of the oil industry. The protein, which is more uniformly distributed, is an important ingredient in animal feed.

FEED GRAIN INDUSTRY

Maize is an important grain in the compound feed industry in New Zealand. It is the main energy source in feed for poultry and pigs in the North Island, having replaced barley in the late 1960's. Currently, maize supplies about 63% of the feed grain used in the North Island, 1% of the feed grain used in the South Island, and 40% of the total feed grain used in New Zealand (Table 2).

Table 2: Feed grain used in the North and South Islands of New Zealand (thousands of tonnes/year).

	North Island	South Island	Total
Maize	140	2	142
Wheat	25	57	82
Barley	57	70	127

Poultry consume about 50% of the manufactured feed produced in New Zealand, equally divided between layers and broilers, while pigs consume about 30% (Table 3).

Maize, barley and wheat are interchangeable in poultry and pig rations, the grain used depending on availability

Table 3: Major feed users in New Zealand (thousands of tonnes/year).

Industry	Quantity
Poultry (layers)	160
Poultry (broilers)	150
Pigs	200
Others	120
Total	630

and price. Maize has a lower crude protein concentration than wheat or barley but has a higher gross energy content (Harris and Douglas, 1981). For pigs and poultry, the protein in maize is deficient in lysine and tryptophan and the level of these amino acids in maize is lower than in wheat or barley.

WET MILLING INDUSTRY

The wet milling industry, sited in Onehunga, produces starch and maize oil. It is now the only source of starch in New Zealand, the wheat starch plant having been closed in 1983. The basic process is shown in Fig. 2.

The bulk maize arrives at the weighbridge, where it is sampled and weighed. Immediate checks are made for moisture content and stress cracks and indicative tests are made for aflatoxins. If the maize fails these tests it is rejected. If accepted, the maize is sent to the silo and a representative sample is sent to the laboratory for further testing. Maize in storage is regularly turned and moisture levels monitored.

When required, the grain is cleaned and sent to the starch plant where it is steeped in stainless steel tanks which contain approximately 30 tonnes of maize in a weak sulphurous acid solution kept at approximately 52°C. Steeping aids starch recovery by softening the kernels for grinding, facilitating disintegration of the protein that holds the starch granules together and removing soluble components. The sulphurous acid also limits fermentation.

The steep time can vary from 30 to 45 hours. At the end of this period, the steep water contains approximately 6% soluble substances; this soluble fraction contains 35-45% protein on a dry weight basis. The steep water is concentrated and used in animal feeds.

The steeped maize, containing about 45% moisture and fully softened, is passed through a degerminating mill. This consists of a stationary and a rotating metal plate with projecting teeth which tear open the kernels to release the components. The ground material passes through liquid cyclones, where the germ is separated whole from other components, washed free of starch and dried. The underflow from the hydrocyclones is further ground to release the remainder of the starch. The starch-gluten complex is then passed over DSM screens to remove fibre. These fibres are dewatered in a wedge wire press and dried for use in animal feed. The starch and gluten are then separated in high speed centrifuges. The heavier starch

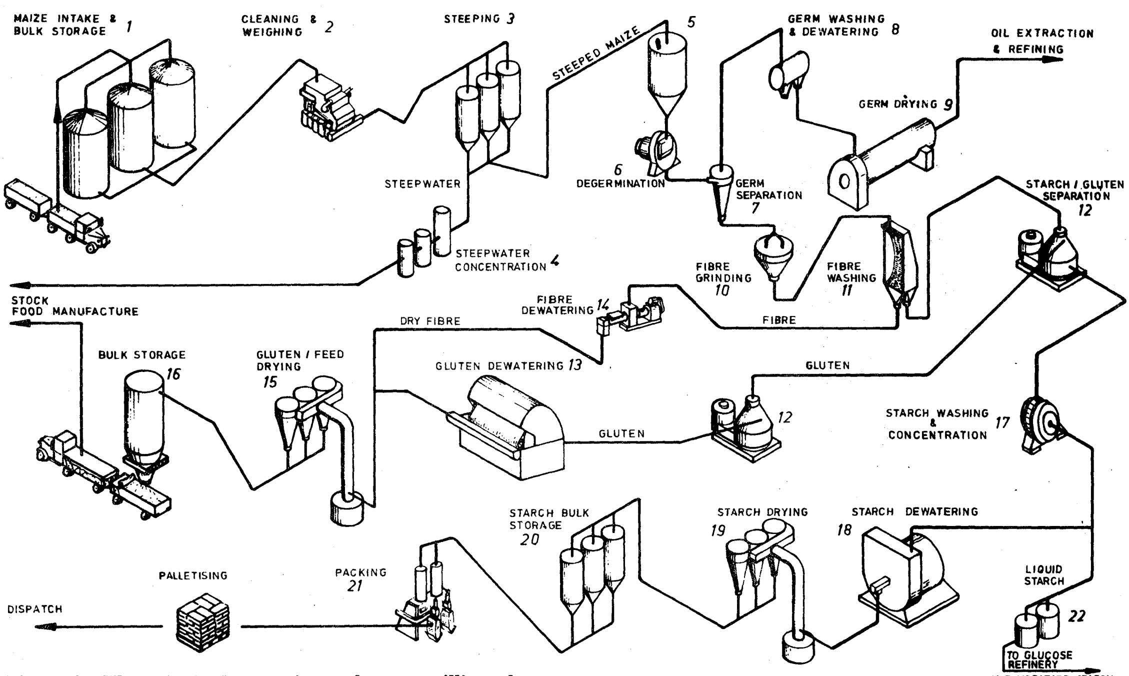

Figure 2. The principal operations of a wet milling plant.

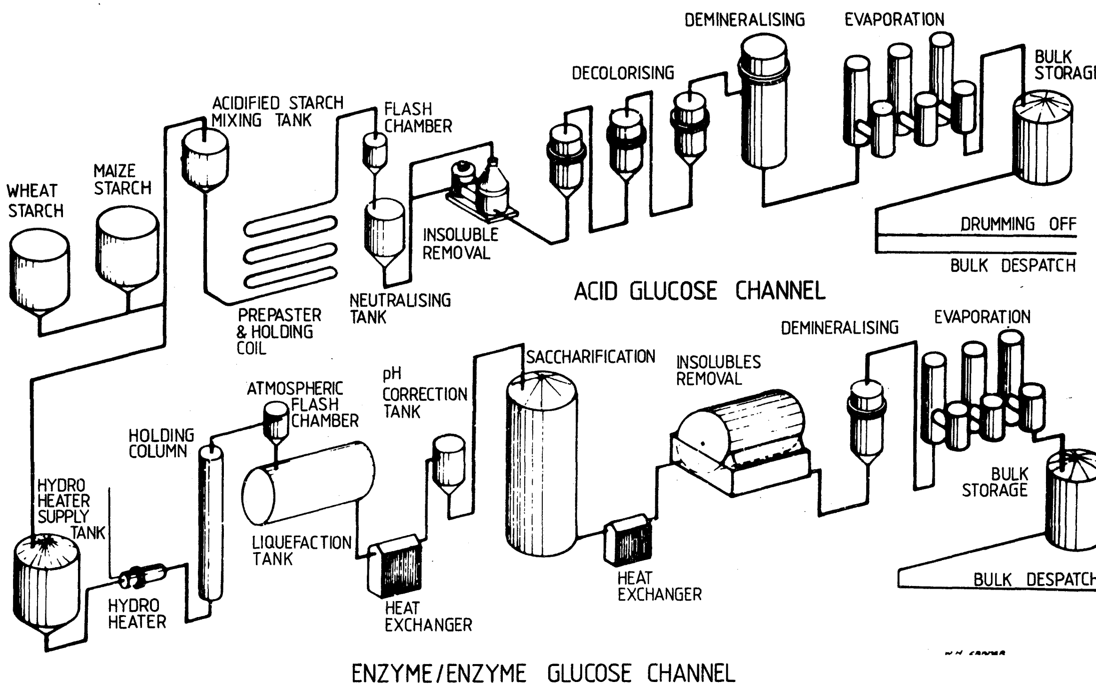

Figure 3. The principal operations of a glucose refinery.

fraction is washed, concentrated before further processing as a starch slurry, or centrifuged to produce wet cake which is dried. The gluten is removed from the water on a rotary filter and dried.

Starch slurry is treated in several ways. Treatment with acids, chlorine, esters or heat produces a range of modified starches which are used in many industries. For example, acid modified starch helps bind fibres to produce paper with improved burst and tensile strength, while chlorinated (oxidised) starch is used in the production of high quality printing or writing papers with a smooth hard surface. Pregelatinised starches, prepared by heating and drying starch slurry, are used as wallpaper pastes and, because of their water holding properties, have numerous applications in the food industry.

When the starch slurry is acidified and heated to gelatinise the starch, and kept hot under pressure for a short period, the resultant solution is sweet (Fig. 3). The degree of sweetness depends upon the degree of hydrolysis of the starch molecules. Another, more recent process, gelatinises the starch by heating and then uses an enzyme to solubilise the starch. A second enzyme completely hydrolyses the soluble starch molecules to dextrose which is frequently sold as glucose. Variations of this enzymatic procedure produce a range of syrups with different sugar compositions, such as liquid glucose, high maltose syrup and high dextrose syrup. These products are used in pharmaceutical preparations, jams, canned fruit, beverages, confectionary, ice-cream, brewing, ready-made icings and other food products. More recently, a third enzyme has been applied to convert dextrose to fructose, which is approximately twice as sweet as cane sugar. This product has found a considerable market in the U.S.A. but has not yet been produced in New Zealand.

Dried starch has a large number of uses. It is used in cooking as cornflour, as an adhesive in poster pastes, and in food processing as a bonding agent, anticaking agent and dusting powder.

The most valuable product of wet milling on a per weight basis is maize oil. It is polyunsaturated and after purification has a ready market as a household oil and in the manufacture of margarine and other food products.

DRY MILLING INDUSTRY

The dry milling industry, with main factories in Gisborne and Auckland, produces a range of food products (Table 4).

Cleaned maize is dampened quickly with hot water to toughen the germ and the pericarp. The grain is then milled in a degermination mill, which breaks open the kernel causing minimum damage to the germ. The objective of this system is to recover the maximum amount of low fat, low fibre endosperm in large pieces free from the germ and pericarp. The production of a range of endosperm products is then carried out using asperation, roller mills, gravity

Table 4: Products of the dry milling industry and their end use.

Product		Separate by screening Through No.	Over No.	End use
Flaking grits	No. 1	4 wire	6 wire	Corn flakes
Flaking grits	No. 2	6 wire	10 wire	Breakfast foods
Semolina	No. 1	10 wire	32 wire	Snack products
Semolina	No. 2	32 wire	40 wire	Snack products
Polenta	No. 1	40 wire	44 wire	Dusting powder
Polenta	No. 2	44 wire	60 wire	Snack and prepared foods

tables, separators, sifters and purifiers (Table 4). If necessary the products are dried.

ALCOHOL MANUFACTURE

Alcohol, in the form of potable alcohol for the blending of gins and vodka, has been produced in New Zealand using maize. The alcohol used in spirits blending is traditionally grain alcohol from maize or barley. It is produced by cooking the maize, modifying the mash by enzymes, either natural or manufactured, fermenting with yeast and recovering the alcohol by distillation.

GRAIN DRYING AND STORAGE

Maize milling industries require high quality grain to produce high quality products; the quality of the grain depends on the way in which it was harvested, dried and stored.

Modern agricultural practice is to harvest the grain at a moisture content of between 20% and 30%, and to artificially dry it in hot air driers to 14% moisture content or less. If the drying process is not properly controlled, undesirable changes occur in the maize kernel. The major problems are stress cracking, difficulty in separating constituents during wet milling and oil discolouration.

Stress cracking occurs in maize grain which has been heated to temperatures higher than 60 °C and then cooled rapidly. Stress cracked maize shatters easily during handling and is more likely to be infected by fungi than maize without stress cracks. Stress cracks in the germ produce undesirable oil losses in wet milling and undesirable oil contamination of grits in dry milling.

Constituent separation difficulties occur with grain which has been dried at temperatures greatly in excess of 60 °C. The separation of starch from gluten becomes difficult, the processing rates are reduced, and finished product quality is reduced. If temperatures are higher still, the oil darkens and becomes useless for anything except soap manufacture. If drying temperatures exceed 90 °C, grain protein may be denatured causing major losses in the feed value of the grain.

Mould can develop in pockets of high moisture grain (above 15%) in a silo and can spread rapidly because the carbohydrates consumed by the mould produce water which in turn raises the moisture content of surrounding grain. Furthermore, respiration of the mould raises the grain temperature and in some cases temperatures can become high enough to modify the starch, discolour the oil and ultimately cause a fire. Turning the grain in the silo complex every three or four weeks reduces heating problems and should be a standard procedure. For long term storage, without turning, the moisture content of all the grain should not exceed 13% (Aldrich *et al.*, 1975).

Where maize has become mouldy in storage a potential risk is mycotoxin development. Mycotoxins are toxic substances produced by fungi and when present in feed grains, they can retard the growth of poultry and pigs, or at higher levels can kill. Aflatoxin, a type of mycotoxin, can cause cancer and other serious diseases in higher animals, including man, when digested in very small quantities. Correct harvesting, drying and storing of maize reduces the incidence of mould and so the risk of mycotoxin development and should be an objective of all sectors of the maize industry.

REFERENCES

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